BASIC GEOLOGIC AND HYDROLOGIC INFORMATION, BRADSHAW MOUNTAINS, YAVAPAI COUNTY, ARIZONA

by

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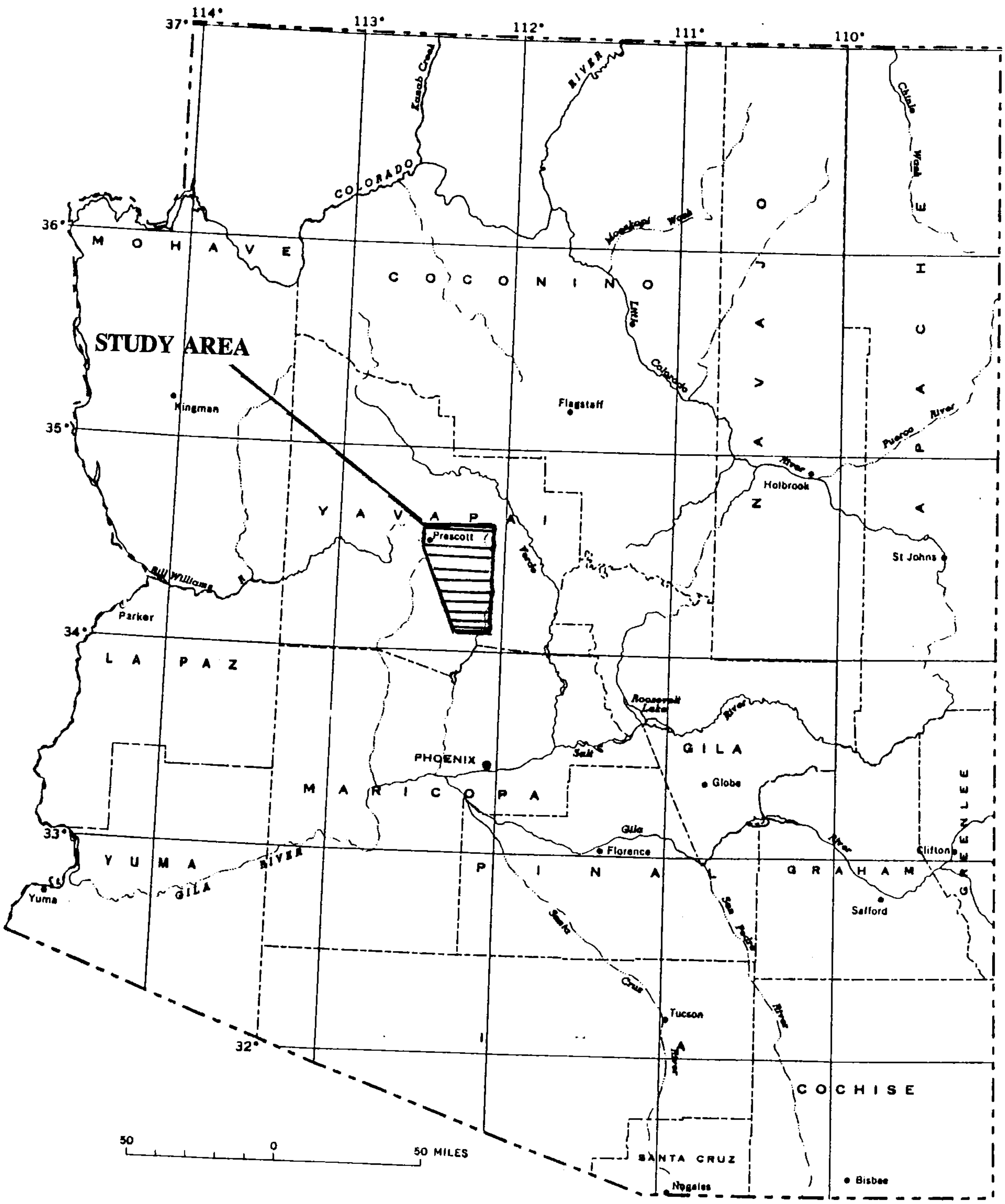
VOLUME 2 (maps):

INTRODUCTION

This report is the result of a preliminary environmental assessment of the impact of past mining activities on water quality in the Bradshaw Mountains area. The assessment is Phase 1 of a multiphase project. The ultimate goals of the project are: 1) to focus on a relatively small portion of the Bradshaw Mountains for further characterization; (2) to mitigate water quality problems at the selected site; and (3) to develop general guidelines for containment and/or abatement of mining-related water contamination problems. Phase 1 was executed by the Arizona Geological Survey in cooperation with the Arizona State Land Department and under contract with the Arizona Department of Environmental Quality.

Phase 1 involved the collection, review and evaluation of existing geologic, hydrologic and mining information on the Bradshaw Mountains area (see page 2 for study area location). The results of Phase 1 include: an overview of the data which were readily available; a general sense of where the most suitable areas for further study are; and what the largest data gaps are.

The first section of this report essentially lists the information that was gathered. Section 2 contains discussion and observations made based on the data collected. Conclusions are given in Section 3.


STUDY AREA
114°
113°
112°
111°
110°
37°
36°
35°
34°
33°
32°
M O H A V E
C O C O N I N O
N A V A J O
A P A C H E
Y A V A P A I
L A P A Z
M A R I C O P A
G I L A
Y U M A
P I N A L
G R A H A M
G R E E N L E E
C O C H I S E
S A N T A C R U Z
COLORADO RIVER
Kanab Creek
Moenkopi Wash
Little Colorado River
Chinle Wash
Puerco River
Verde
Bill Williams R.
Salt
Roosevelt Lake
Gila River
GILA RIVER
Santa Cruz
San Pedro River
Kingman
Flagstaff
Holbrook
St Johns
Prescott
Parker
PHOENIX
Globe
Florence
Clifton
Safford
Yuma
Tucson
Nogales
Bisbee
50
0
50 MILES

SECTION 1: INFORMATION GATHERED FOR PHASE I

1) Bibliography

An annotated bibliography of published and unpublished geologic, hydrologic and mining information available on the Bradshaw Mountains area is provided in Appendix 1. The bibliography serves as the reference section for this report.

2) Geologic and Mining Information

a) A geologic map compiled from several different source maps is provided as Plate 1 (Rock-Type Map of the Bradshaw Mountains Area). This map, and all other maps created for this report, is at a scale of 1:100,000. The geologic maps which were used to construct Plate 1 were at various scales, therefore the level of detail of the rock-type map varies. The boundaries of the maps used to construct Plate 1 are shown on Plate 2 (Index to Geologic Mapping in the Bradshaw Mountains Area).

b) The boundaries of the metallic mineral districts which occur in the study area are shown on Plate 3 (Metallic Mineral Districts in the Bradshaw Mountains Area).

c) A map showing lineaments, mine locations and suspected mine tailings pile locations is provided as Plate 4 (Prescott Mining Project Lineaments). Aerial photographs and U.S. Geological Survey 7.5 minute topographic maps were used to create Plate 4.

d) Locations of mines which have records of ore production in exceedence of 500* tons are shown on Plate 5 (Prescott Mining Project Named Mines). Reported ore production ranges for individual mines, and notes as to whether milling has occurred at a given mine are also shown on Plate 5.

Text which compliments Plate 5, by providing information on milling processes, mining activities, commodities produced, ore mineralogy, etc., for individual mines, is provided in Appendix 2. Mines are categorized in the text by metallic mineral district and are listed in order of decreasing magnitude of reported ore production. A brief description of the ore processing techniques which were employed at the mines is given at the end of Appendix 2. The information in the text was taken from the U.S. Geological Survey Mineral Resources Data System (MRDS) and from other sources referenced in the text.

The mines for which information was gathered are listed below by metallic mineral district:

Agua Fria District: Binghampton, Big Bug, Copper Queen, Stoddard

Big Bug District: Iron King, Hackberry, Lone Pine, Butternut, Kit Carson, Huron, Boggs

Black Canyon District: French Lilly, Golden Belt, Golden Turkey, Brooks, Silver Cord, Thunderbolt

Groom Creek District: Home Run, Midnight Test, Gold Basis, Alma, Monte Cristo (or King Kelley), Cornucopia, Pine Grove

Hassayampa District: Oro Flame, Golden Charm (or Golden Eagle), Ruth, Independence, Blue Dick

Mayer District: Blue Bell, Desoto

Mount Union District: Davis-Dunkirk, Mount Union, Storm Cloud, Cash, Senator, Big Pine, Crook (or Crook & Western), Venezia, Money Metals, Sheldon Superior

Peck District: Swastika, Peck

Richinbar District: Richinbar

Ticonderoga District: Arizona National, Lelan-Dividend, Little Jesse, Red Rock, Postmaster, Silver Belt, Independence 2

Tiger District: Crown King, Wildflower, Lincoln, Union, Del Pasco

Turkey Creek District: Bodie, War Eagle

Walker District: Sheldon, Poland, Mudhole, Amulet, Pine Mountain, Black Diamond, New Strike, Oro Plata, Combination, Blue John (Wedge), Hidden Treasure

*To limit the number of mines which would be researched to a manageable quantity, a lower limit of recorded ore production was selected. The value of 500 tons is arbitrary, but reasonable, in that little information would likely be available for mines which produced lesser amounts of ore.

3) Topography

a) A topographic map of the study area was created for reference and is provided as Plate 6 (Prescott Mining Project Contour Intervals).

4) Well and Water Level Information

Information on well location, well construction and water level elevation was primarily drawn from the Arizona Department of Water Resources' Groundwater Site Investigation (GWSI) data base and the well-registry data base (55-file). The GWSI data base contains several fields of information for individual wells, including the perforation interval, casing diameter, casing material and availability of a geologic log. The 55-file contains names and addresses of well owners, in addition to well construction information.

a) Well elevation and depth maps are provided as Plate 7 (Prescott Mining Project Well Altitude) and Plate 8 (Prescott Mining Project Well Depth) respectively.

b) A water level elevation and depth to water map is provided as Plate 9 (Water Level Elevation and Depth to Water).

c) Locations of some of the wells contained in the 55-file are shown on Plate 10 (Prescott Mining Project Wells from Pres55 File). Unfortunately the locational information in the 55-file is by township and range, and only a fraction of the locational information was amenable to plotting. Well locations which appear on the map were converted to an ARC/INFO plotting format using a DWR conversion scheme which is no longer available. Therefore the remaining well locations could not be converted to an ARC/INFO plotting format.

5) Water Quality Information

a) Major anion and cation abundance, pH and specific conductance data for several groundwater samples are shown on Plate 11 (Major Cation and Anion Abundance, pH & Specific Conductance).

b) Plate 12 (Groundwater, Surface Water and Tailings/Spoil Pile Sample Analysis Data) shows the results of groundwater, surface water and tailings/spoil pile sample analalyses conducted for various studies.

SECTION 2: OBSERVATIONS AND DISCUSSION

1) Geology

The geology of the study area is complex and has been studied and written about by several investigators. References are provided in Appendix 1 to interpretive and descriptive geologic writings and maps which can be referred to once specific areas for further study are selected. A brief, generalized description of the regional and study area geology is provided below.

a) Regional Geology

The study area is located in the Transition Zone physiographic province, in central Arizona, which lies between the Basin and Range province to the south and the Colorado Plateau to the north. The Transition Zone is characterized by diversely oriented mountains containing some of the oldest rocks known in Arizona.

Rocks in central Arizona generally fall into one of 3 categories: Proterozoic rocks which range from 1,750 m.y. (million years); Paleozoic rocks deposited from 570 to 250 m.y. ago; and Tertiary deposits and volcanic flows which accumulated during the past 25 m.y. (Elston, 1984)

Proterozoic rocks of central Arizona consist of: ancient sedimentary and volcanic strata which were metamorphosed shortly after accumulation; younger, less metamorphosed plutonic rocks; and relatively slightly metamorphosed sedimentary strata including quartzite and carbonate rocks. (Elston, 1984)

Horizontally stratified Paleozoic rocks present across the Colorado Plateau are also present in central Arizona. Deposition of these rocks occurred during a time when seas encroached on and crossed Arizona, beginning about 570 m.y. ago. (Elston, 1984)

The relatively young volcanic and sedimentary strata of the Cenozoic accumulated after one or more increments of regional uplift. The present landscape of central Arizona probably has its origin in an episode of regional uplift that is estimated to have begun 38 m.y. ago. Evidence of this episode includes red fanglomerate deposits which contain regolith stripped from formerly low-lying surfaces. Uplift was accompanied and followed by vigorous erosion that led to the development of the strong topographic relief which characterizes the region. Volcanic activity in the area began during Oligocene time after the deposition of the red fanglomerate. (Elston, 1984)

b) Bradshaw Mountains Area Geology

The general distribution of rock-types in the area is shown on Plate 1. Rocks present in the Bradshaw Mountains area consist chiefly of Proterozoic rhyolitic, andesitic and basaltic metavolcanics, metasedimentary rocks, and granitic and gabbroic intrusives which have experienced varying levels of deformation and mineral alteration. Other rocks present include Cretacious or Tertiary intrusives and Tertiary volcanics and sedimentary rocks.

Two major shear zones have been identified in the area and are discussed in the literature. The Shylock zone is a north-south trending linear feature which runs through the study area from the southern boundary near Black Canyon City, northward, just to the east of Mayer, and to the northern boundary near Humboldt. The Chapparal zone is visible (on aerial photographs) to the northeast of Walker and trends northeast. Displacement along the Shylock (active only during the Proterozoic) and Chaparral shear zones occurred more than 1,600 m.y. ago. (Elston, 1984)

Another lineament zone which was apparent on aerial photographs also trends northeast and occurs north of the Crown King area. Many other smaller linear features were identified using aerial photographs. Major rock units shown on Plate 1 express a north to northeast trend in concordance with trends expressed by linear features on Plate 4.

Ore bodies in the area occur as ore shoots in veins and as massive sulfide deposits. Commodities derived from these deposits include gold, silver, copper, tungsten, zinc, lead and molybdenum (see Plate 3 and Appendix 2).

Studies which focused on relationships between major shear zones and lineaments and groundwater flow in the study area were not found. The extent to which lineaments may act as conduits for groundwater flow is dependent upon the degree of fracture porosity, aperture and connectiveness. Plate 4 provides a general sense of fracture zone distribution. The knowledge of major fracture zone distribution may aid in focusing in on a specific portion of a study area for groundwater flow characterization (for example, in a scenario where supply well locations and mine and tailings pile locations occur along the same fracture zone).

2) Mines and Milling

Of chief interest in the literature search on mines with recorded ore production exceeding 500 tons was the history of milling and the processes involved at individual mines. Ore processing has occurred in various forms at many of the mines investigated. Some common processes which were employed were amalgamation and flotation, and an early method of ore processing was through the

use of arrastres. Mercury was an integral component of the amalgamation process and was also used in treating ores from arrastres. Cyanide was commonly used in the flotation process. A brief description of these processes is given at the end of Appendix 2 and includes information on common reagents which were used.

Processing by flotation was reported to have occurred at the following mines: Binghampton, Copper Queen, Stoddard, Iron King, French Lilly, Golden Belt, Golden Turkey, Silver Cord, Thunderbolt, Oro Flame, Davis-Dunkirk, Storm Cloud, Sheldon Superior, Swastika, Richinbar, Lelan-Dividend, Crown King, Union, Sheldon and Amulet. Mines for which the use of cyanide was specifically mentioned in the literature include the following: Independence, Cash, Peck, Big Pine and Crown King. Processing by amalgamation was indicated to have occurred at the following mines: Midnight Test, Pine Grove, Golden Charm, Mount Union, Red Rock, Lincoln and Mudhole. Arrastres were employed in ore processing at the Del Pasco mine. Ore processing occurred at several other mines via ball mills, stamp mills etc. (see Appendix 2).

Another aim of the literature search on mining activities was to gain some insight into whether suspected tailings/spoil piles, which were plotted on Plate 4, are indeed tailings piles. Plate 5 shows that some of the investigated mines, indicated as having milling histories, are in the same location as suspected tailings/spoil piles. Some examples are the Midnight Test, Amulet, Oro Flame, Red Rock, Cash and Lincoln. It is probable that at least a portion of the waste piles present at these sites consist of tailings. Site visits with possible sample collection for analysis is the best way to determine whether tailings exist at a site, and if so, the volume and composition of the tailings.

3) Groundwater Flow and Depth

Water level elevations, and depth to water for some of the wells which occur in the study area are shown on Plate 9. A comparison of Plate 9 with Plate 1 indicates that many of the wells shown on Plate 9 were drilled in unconsolidated to consolidated sedimentary rocks. Groundwater flow patterns in these units appear to mimic surface drainage patterns (see Plates 6 and 9).

Water level elevation data was drawn from the GWSI data base which contains information from several different sampling/measurement exercises. An effort was made to use elevation data which were collected over a relatively short period of time.

Water elevation data for other portions of the study area, especially heavily mined bedrock areas, appear sparse to non-existent, although many wells exist (see Plate 10 and 55-file). As the project progresses it may be desirable to conduct a water level

survey in a local area of interest in order to gain some insight into the local flow regime. This would require the location of a group of wells which penetrate the same hydrostratigraphic unit and for which reliable surface elevation data have been created.

Several wells which have been completed to depths of 50 feet or less are shown on Plates 8 and 9. For this study, water level data for these wells is used to give an approximate sense of depth to shallow groundwater. Depth to water for shallow wells ranges from 3.99 feet to 30.89 feet. Shallow groundwater was measured at depths of 3.99 feet, 8.38 to 20.40 feet and 22.40 feet in the vicinity of the Crook, Butternut and Hackberry mines respectively (see Plates 5 and 9).

4) Groundwater and Surface Water Quality

a) pH and Specific Conductance

Plate 11 shows Stiff diagrams for several wells and also the results of pH and specific conductance analyses. Groundwater pH values ranged from 6.9 to 9.0 (typical for groundwater). Specific conductance ranged from 415 micromhos to 2300 micromhos. Several wells exhibited specific conductance values above 834 micromhos, suggesting total dissolved solids (TDS) concentrations in excess of 500 ppm (secondary drinking water standard). High TDS might be expected in groundwater in low permeability environments with relatively high residence times.

b) Metals

Chemical concentrations in surface water and groundwater which exceeded drinking water standards (Maximum Contaminant Levels and/or Human Health Based Guidance Levels) were plotted. Analytical results of several tailings/spoil pile samples were also plotted.

Results of surface water sample analyses indicated the presence of several contaminants including arsenic, cadmium and mercury (see Plate 12). Tailings/spoil pile analytical results indicated possible source contaminants present in the parts per million to parts per thousand range.

Concentrations of arsenic and metals including cadmium, mercury, lead, molybdenum, manganese and zinc, have exceeded drinking water standards and/or guidelines in several wells and springs (see Plate 12). The data however, are sparse and scattered and no data were found for the central to western-central portion of the study area. In groundwater, the highest arsenic concentration (980 micrograms/liter) plotted on Plate 12 occurred in a well near Interstate 17, between Cordes Junction and Black Canyon city.

c) Note on the Importance of Determining Background Water Quality

Due to the presence of highly mineralized zones in the Bradshaw Mountains area, the possibility that elevated levels of arsenic, molybdenum, lead etc. are due to natural interaction of groundwater and the geologic media exists. Therefore an important aspect of the Phase II sampling and analysis effort will be determining, or attempting to determine natural background groundwater quality, so that there is some basis for determining whether poor water quality is due to past mining practices or due to natural dissolution of minerals.

d) Mine Locations Which May Be Most Suitable for Determination of Background Water Quality

Several mines located in the Lynx Creek/Hassayampa River area which have milling histories, relatively low ore production records, and which may be relatively well situated for determination of background water quality because they appear to be either located upslope of surrounding mines or lie on local drainage divides (see Plates 5 and 6) include the Midnight Test, Gold Basis, Black Diamond, Crook, New Strike and Money Metals mines. Locating a mine which is truly isolated hydraulically from other mines may not be possible, but selection of a site for characterization with a minimum of potential external sources of contamination is desirable.

Some other mines in the study area (outside of the Lynx Creek/Hassayampa River area) which appear to be surrounded by relatively few mines or which are upslope of other mines, include the Red Rock, Ruth, Butternut and Richinbar mines. The Richinbar may most nearly approach isolation since few other mines seem to have been established nearby. However there appears to be little or no water quality data for areas which surround these mines.

e) Lynx Creek and Hassayampa River Area

Analytical results of samples collected by Daniel B. Stephens and Associates Inc., (1990) along the Hassayampa River and Lynx Creek indicate several areas of poor surface water quality (see Plate 12). Surface water pH values ranged from 2.5 to 8.2. Low pH values may be tied to the abundance of sulfide minerals which have been mined and processed in the area.

In contrast to surface water quality, the three groundwater samples collected from the area and analyzed indicate water of relatively good quality. The pH values measured ranged from 6.6 to 7.5, and drinking water standards were not exceeded in that sampling round. The neutral pH values may be related to a strong buffering capacity of groundwater in the area, resulting in conditions which are less favorable to trace metal transport. Establishing a better understanding of the hydrogeochemistry of an area selected for

further study may be of interest at a later stage of the project to gain some insight as to the local groundwater conditions which may favor or inhibit trace metal transport.

A comparison of Plate 4 with Plate 10 shows a grouping of wells in the Walker area along Lynx Creek which parallels a linear feature (possibly a fracture zone). As can be seen on Plate 4 a group of mines and tailings/spoil piles occurs in this area (some of these mines were described in the Lynx Creek/ Hassayampa River study, and spoil pile samples were collected from the Blue John and Senator mines for analysis). The facts that mines, tailings and wells used for domestic supply occur in the same area, and that water quality in the area has already received some attention, qualifies this area as a candidate for further study in Phase II.

f) Areas of Poor Water Quality and Proximity of Possible Sources

A comparison of Plate 12 with Plates 4 and 5 shows that some locations where groundwater contamination appears to have occurred are in close proximity to mine locations and/or suspected tailings/spoil pile locations. Several examples of these locations, which may warrant further investigation are given below.

A suspected tailings location in the extreme northeast portion of the study area lies within about 1200 feet of a spring which exhibited the following concentrations: 95 micrograms per liter of arsenic and 30 micrograms per liter of molybdenum. In the area north of the Blue Bell mine, a well located about 0.5 miles down slope from a mine location was sampled and analytical results indicated the following concentrations: 237 micrograms per liter arsenic, 9 micrograms per liter cadmium, 93 micrograms per liter molybdenum and 1882 micrograms per liter zinc. Sample analysis results from a spring location in close proximity to the Stoddard mine indicated concentrations of arsenic at 147 micrograms per liter and molybdenum at 28 micrograms per liter. A well north of the Hackberry mine area is situated near a dredge tailings dump and exhibited concentrations of 101 micrograms per liter arsenic and 46 micrograms per liter molybdenum. Another well south of the Hackberry mine area exhibited concentrations of 131 micrograms per liter arsenic and 55 micrograms per liter molybdenum, and is located about 0.25 miles from a mine.

g) McCabe Mine and Golden Belt Mine

Plate 12 shows some sample analysis data taken from the Golden Belt mine study (Labbat-Anderson, Inc., 1991) and the McCabe mine study (Hargis and Associates, 1991). Additional data is available on these sites in the reports mentioned above.

SECTION 3: CONCLUSIONS

1) There is some evidence of surface water and groundwater contamination due to past mining activities in the Bradshaw Mountains area. Surface water contamination is particularly evident in the Lynx Creek and Hassayampa River area and at the Golden Belt mine. Elevated concentrations of metals have been documented at the McCabe mine and were exhibited in samples from several well and spring locations across the study area.

2) Information was gathered on mines in the study area indicating that many have processed ore on site at some time in their history. Amalgamation and flotation were two common types of ore processing techniques which employed the use of mercury and cyanide. The ore which was processed by these techniques contained varying amounts of arsenic, lead, zinc, etc. Many tailings piles which resulted from ore processing are scattered throughout the study area and may act as sources of surface water and groundwater contamination.

3) The highly mineralized geologic media of the region are also a possible source of observed metals concentrations. Discriminating between contamination due to previous mining activities and metals concentrations which occur naturally will be an important aspect of Phase II.

4) Water level elevation data are scarce in much of the study area, with most of the data points occurring in the unconsolidated to consolidated sedimentary units shown on Plate 1. Collection of additional water level data in areas of interest may be desirable in a later stage of the project.

5) Only a partial plot of the wells registered in the study area could be made. A full plot of this data would show the distribution of wells available for possible sampling.

6) Plate 1 suggests that detailed geologic map availability for the portion of the study area which is below 34^{0} 15′ north latitude, is limited.

APPENDIX 1:
ANNOTATED BIBLIOGRAPHY

GEOLOGIC AND MINERALOGIC STUDIES

*Anderson, C.A. 1972, Precambrian Rocks in the Cordes Area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1345, 36 p.

Lithologic and stratigraphic descriptions of Precambrian, Cretaceous or Tertiary, and Cenozoic rocks of the Cordes area. Structural disposition of Precambrian rocks, ore body characteristics and mining activities are discussed. Results of geochemical analyses are presented. A geologic map (scale 1:24,000) and cross sections of the Cordes area are included.

Anderson, C. A., and Blacet, P. M., 1972a, Precambrian Geology of the Northern Bradshaw Mountains, Yavapai County, Arizona: U. S. Geological Survey Bulletin 1336, 82 p.

Lithologic and stratigraphic description of Precambrian, Cretaceous or Tertiary, and Cenozoic rocks of the Northern Bradshaw Mountains. Results of geochemical analyses are presented. Structure and metamorphism in the area are discussed and mining activities associated with ore bodies in the area are described. Geologic maps of the NE1/4 Mount Union quadrangle (scale 1:24,000) and the NW1/4 Mayer quadrangle (scale 1:24,000), and accompanying cross sections are provided.

Anderson C.A., and Blacet, P.M., 1972b, Geologic map of the Mount Union Quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-997, scale: 1:62,500.

Anderson C.A., and Blacet, P.M., 1972c, Geologic map of the Mayer Quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-996, scale: 1:62,500.

Anderson, C.A., and Creasey, S.C., 1958, Geology and ore deposits of the Jerome area, Yavapai County, Arizona: U.S. Geological Survey Professional Paper 308, 185 p.

Lithologic, stratigraphic and structural description of Precambrian, Paleozoic and Cenozoic rocks. History, mineralogy and general characteristics of ore deposits is provided along with information on various mining districts. A geologic map of the Jerome area (scale 1:24,000) and cross sections are provided.

Anderson, C.A., and Creasey, S.C., 1967, Geologic map of the Mingus Mountain Quadrangle, Yavapai County, Arizona: U.S. Geological Survey Map GQ-715, scale: 1:62,500.

Anderson, C.A., and Silver, L.T., 1976, Yavapai Series--A greenstone belt, *in* Wilt, J.C., and Jenney, J.P., eds., Tectonic Digest: Arizona Geological Society Digest, v. 10, p. 13-26.

Discussion of Yavapai Series greenstone belt and its developmental relationship to downwarping or island arcs. Descriptions of the Precambrian volcanic and volcanoclastic groups of the Yavapai Series, associated plutons and volcanic-sedimentary assemblages are given. A geologic map of the Prescott, Mingus Mountain, Mount Union, and Mayer quadrangles is incorporated in the text.

Anderson, Phillip, 1986, Geologic overview of the transect from the Iron King to the Copper Queen mine, *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the southwest: Arizona Geological Society Digest, V. 16, p. 365-369.

Describes metamorphic and alteration features, major structural features and major stratigraphic units. Descriptions of the Black Canyon Creek Group and Precambrian volcanogenic mineral deposits. Includes a geologic map of the Agua Fria River region, (scale: 1 in. = 1 mi.).

Anderson, Phillip, 1989, Stratigraphic framework, volcanic-plutonic evolution, and vertical deformation of the Proterozoic volcanic belts of central Arizona, *in* Jenney, J. P., and Reynolds, S. J., eds., Geologic Evolution of Arizona: Tucson, Arizona Geological Society Digest 17, p. 57-147.

Proposes new stratigraphic framework for the Prescott-Jerome volcanic belt. Describes geochemistry, petrology and structure of the volcanic belts. Discusses and describes plutonic suites and metamorphism of the Prescott region. Includes a geologic map (scale 6 cm = 25 km) of the Prescott-Jerome region and a geologic map of the Bradshaw Mountains-Prescott region, showing major plutonic bodies (scale 1 in. = 10 mi.).

Anderson, Phillip, Guilbert, J.M., 1979, The Precambrian massive sulfide deposits of Arizona-A distinct metallogenic epoch and province, *in* Ridge, J.D., ed., Papers on mineral deposits of western North America: Nevada Bureau of Mines and Geology, Report 33, p. 39-48.

Discussion of occurrence and nature of Proterozoic massive sulfide deposits, including features, age and tectonic setting.

Arizona Bureau of Mines, 1958, Geologic map of Yavapai County, Arizona: scale 1:375,000.

Argenbright, D.N., 1985, Geologic map and Proterozoic structure of Crazy Basin area, Yavapai County, Arizona: Arizona Geological Survey Contributed Map Series CM-91-D, scale 1:10,000.

Billingsley, G.H., Conway, C.M, and Beard, L.S., 1988, Geologic Map of the Prescott 30- x 60-minute quadrangle, Arizona: U.S. Geological Survey Open-File report 88-372, scale 1:100,000.

Blacet, P.M., 1966, Unconformity between gneissic granodiorite and overlying Yavapai Series (older Precambrian), central Arizona: U.S. Geological Survey Professional Paper 550-B, p. B1-B5.

Description of structural setting, stratigraphy and lithology. Results of geochemical analyses are presented and a generalized geologic map of the Brady Butte area is included in the text.

Blacet, P.M., 1985, Proterozoic geology of the Brady Butte area, Yavapai County, Arizona: U.S. Geological Survey Bulletin 1548, 55 p.

Description of lithology, stratigraphy, structure and metamorphic zonation of Proterozoic rocks in the Brady Butte area. Late Cretaceous or early Tertiary, and Cenozoic rocks of the area are also described and results of geochemical analyses are presented. A geologic map, with cross sections, of the Brady Butte area (scale 1:24,000) and a generalized geologic and structural map of the Brady Butte and surrounding area (scale 1:62,500) are included.

Blandy, J.F., 1883, The mining around Prescott, Arizona: Transactions of the American Institute of Mining Engineers, v. 11, p. 286-291.

Description of geology, vein mineralogy and mining in the Prescott area.

Clements, B.P., 1991, Precious metal vein mineralization in the Bradshaw Mountains region, Yavapai County, Arizona: Tucson, University of Arizona, M.S. thesis, 150 p.

Summary description of structural and tectonic setting of region. Description of veins in select mining districts and results of geochemical analyses. Classification of vein types.

Cox, Ronadh, Karlstrom, K.E., and Cullers, R.L., 1991, Rare earth element chemistry of Early Proterozoic argillites, central Arizona: Constraints on stratigraphy, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 57-66.

Presentation of results of geochemical analyses and stratigraphic interpretation. A geologic map of central Arizona (scale 1cm = 1 km) is included.

Creasey, S.C., 1952, Geology of the Iron King mine, Yavapai County, Arizona: Economic Geology, v. 47, p. 24-56.

Lithologic and structural description of the area, and general discussion of the Iron King ore deposit. Sulfide veins of the area are discussed in detail and geologic maps of the Humboldt region (scale 1 in. = 4000 ft.) and the area southwest of the Iron King mine (1 in. = 530 ft.) are provided.

Darrach, Mark, 1987, Geologic map and Proterozoic structure of the Cleator shear zone, Yavapai County, Arizona: Arizona Geological Survey Contributed Map Series CM-91-G, scale 1:3,000.

Darrach, M.E., Karlstrom, K.E., and others, 1991, Progressive deformation in the Early Proterozoic Shylock shear zone, central Arizona, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 97-116.

Discussion on structural geology of central Arizona, with focus on the Shylock shear zone. A generalized geologic map is included.

DeWitt, Ed, 1976, Geologic map of Mayer-Crown King area, Yavapai County, Arizona, and Metamorphic and chemical data map, Mayer-Crown King area, Yavapai County, Arizona: Arizona Bureau of Geology and Mineral Technology Miscellaneous Map MM-76-B, scale 1:24,000, 2 sheets.

DeWitt, Ed, 1979, New data concerning Proterozoic volcanic stratigraphy and structure in central Arizona and its importance in massive sulfide exploration: Economic Geology, v. 74, no. 6, p. 1371-1382.

Description and discussion of stratigraphy and structure and conclusions, including need for revision of published nomenclature in the Mayer-Crown King area. Simplified geologic map and cross section, and proposed stratigraphic models of the Mayer-Crown King area.

DeWitt, Ed, 1980, New data concerning Proterozoic volcanic stratigraphy and structure in central Arizona and its importance in massive sulfide exploration-A reply: Economic Geology, v. 75, no. 6, p. 944-945.

Response to comments on structural and stratigraphic interpretations in the Mayer-Crown King area.

DeWitt, Ed, 1989, Geochemistry and tectonic polarity of early Proterozoic (1700-1750-Ma) plutonic rocks, north-central Arizona, *in* Jenney, J.P., and Reynolds, S.J., eds., Geologic Evolution of Arizona: Tucson, Arizona Geological Society Digest 17, p. 149-163.

Results of major- and minor- element analyses conducted on samples of plutonic bodies from the Prescott area are presented. Plutonic bodies are grouped into distinct, genetically related suites. Geologic and geochemical descriptions of the suites are given. A simplified geologic map of the area is included.

DeWitt, Ed, 1991, Road log and geologic maps for Arizona Geological Society field trip, spring, 1991, *in* Karlstrom, K.E., ed.,

Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 309-332.

Geologic maps of the Prescott, Mayer and New River Mountains areas (scale 1:100,000).

Gillentine, J.M., Karlstrom, K.E., and others, 1991, Constraints on temperatures of Proterozoic metamorphism in low-grade rocks of central Arizona, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 165-180.

Study of metamorphism in central Arizona including a summary of X-ray diffraction analyses and new fluid inclusion studies. X-ray diffraction profiles and fluid inclusion data are presented and discussed. A geologic map of central Arizona (scale 1 cm = 1 km) is included.

Gilmour, Paul, and Still, A.R., 1968, The geology of the Iron King mine, *in* Ridge, J.D, ed., Ore deposits of the United States 1933/1967: New York, The American Institute of Mining, Metallurgical and Petroleum Engineers, Inc., v. 2, p. 1238-1257.

Lithologic, stratigraphic and structural description of the area. Discussion of area mining and milling and classification and origin of ore bodies.

Higgins, R.E., 1986, Geology of the Copper Queen mine, Mayer, Arizona, *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the Southwest: Arizona Geological Society Digest, V. 16, p. 377-379.

Brief description of structure and lithologic units in the area. Includes a geologic sketch map of the area (scale 1:24,000).

Jagger, T.A., Jr., and Palache, C., 1905, Description of the Bradshaw Mountains quadrangle, Arizona: U.S. Geological Survey Atlas folio 126, 11 p.

Includes geologic description and map of the Bradshaw Mountains quadrangle (scale 1:125,000).

Karlstrom, K.E., 1986, Thrusting and strike-slip faulting during Proterozoic accretion in central Arizona [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 365.

Karlstrom, K.E., Bowring, S.A., and Conway, C.M., 1987, Tectonic significance of an Early Proterozoic two-province boundary in central Arizona: Geological Society of America Bulletin, v. 99, no. 4, p.529-538.

Discussion of evidence for existence of two tectonostratigraphic provinces and structural and age constraints. A generalized geologic map (scale 1 cm = 1 km) and cross sections are included.

Karlstrom, K.E., and Conway, C.M., 1986, Deformational styles and contrasting lithostratigraphic sequences within an early Proterozoic orogenic belt, central Arizona, *in* Nations, J.D., Conway, C.M., and Swann, G.A., Geology of central and northern Arizona: Field Trip Guidebook for Geological Society of America Rocky Mountain Section Meeting, Flagstaff, Arizona 1986, p. 1-25.

Geologic descriptions and geologic maps of select areas.

Keith, S.B., Gest, D.E., and others, 1983, Metallic mineral districts and production in Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 194, 58 p.

Includes duration of production for mineral districts and amounts of metals produced. A map showing the metallic mineral districts of Arizona (scale 1:1,000,000) is included.

Keith, S.B., Schnable, Loraine, and others, 1983, Map, description and bibliography of the mineralized areas of the Basin and Range Province in Arizona: U.S. Geological Survey Open-File Report 84-0086, 129 p. with map, scale 1:500,000.

Keith, S.B., and Swan, M.M., 1986, Proterozoic mineral deposits in central Arizona and vicinity: an example of magmatic and metallogenic heterogeneity over time [abs.]: Geological Society of America Abstracts with Programs, v. 18, no. 5, p. 366.

Krieger, M.H., 1967, Reconnaissance geologic map of the Iron Springs quadrangle, Yavapai County, Arizona: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-504, scale 1:62,500.

Krieger, M.H., 1965, Geology of the Prescott and Paulden quadrangles, Arizona: U.S. Geological Survey Professional Paper 467, 127 p.

Description of lithology, stratigraphy and structure of Precambrian, Paleozoic and Cenozoic rocks of the Prescott and Paulden quadrangles. Information on the economic geology of the area including ore deposits and nonmetallic deposits is provided. The water resources of the Prescott area is also covered. Geologic maps of the Prescott and Paulden quadrangles (scale 1:48,000) and accompanying cross sections are included.

Krieger, M.H., Creasey, S.C., and Marvin, R.F., 1971, Ages of some Tertiary andesitic and latitic volcanic rocks in the Prescott-Jerome area, north-central Arizona: U.S. Geological Survey Professional Paper 750-B, p. B157-B160.

Presentation of results of geochemical analyses of Tertiary volcanics and discussion of geologic relationships and potassium-argon ages. A generalized geologic map of the Cenozoic rocks in the Prescott-Jerome area is included in the text.

Labat-Anderson, Inc., 1991, Site assessment for the Golden Belt mine, Bradshaw Ranger District, Prescott National Forest, May 8, 1991.

Evaluation of potential risks to human health and environment.

Lawrence, J.R., and Dixon, R.L., 1986, Geology of the Spud Mountain tuff in the vicinity of the Iron King mine, *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the southwest: Arizona Geological Society Digest, v. 16, p. 370-373.

Description of the Spud Mountain tuff and soil geochemistry.

Leighty, R.S., Best, D.M., and Karlstrom, K.E., 1991, Gravity and magnetic evidence for an Early Proterozoic crustal boundary along the southern Shylock fault zone, central Arizona, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 135-152.

Complete and residual Bouguer gravity profiles are presented, interpreted and discussed. Figures in text include a geologic map, complete and residual Bouguer anomaly maps and gravity profiles.

Lindgren, Waldemar, 1926, Ore deposits of the Jerome and Bradshaw Mountains quadrangles, Arizona: U.S. Geological Survey Bulletin 782, 192 p.

General descriptions of geology and ore deposits of the region. Detailed descriptions of mining districts of the area. Geologic maps of the Jerome and Bradshaw Mountains quadrangles (scale 1:125,000) are included.

McKee, E.H., and Anderson, C.A., 1971, Age and chemistry of Tertiary volcanic rocks in north-central Arizona and relation of the rocks to the Colorado Plateaus: Geological Society of America Bulletin, v. 82, no. 10., p. 2767-2782.

Description of Late Tertiary geology and presentation of results of Potassium-argon dating and geochemical analyses (of basalts). A geologic map (scale 1 in. = 5 mi.) consisting of the Paulden, Clarkdale, Prescott, Mingus Mountain, Mount Union and Mayer quadrangles is included.

O'Hara, P.F., 1981, The influence of mole fraction of CO_2 on amphibole stability in the Bradshaw Mountains region, central Arizona, *in* Stone, Claudia, and Jenney, J.P., eds.: Arizona Geological Society Digest, v. 13, p. 21-23.

Discusses influence of temperature and mole fraction of CO_2 variation on production of amphibole occurring in Precambrian metamorphosed mafic volcanic rocks and calcareous sediments of the Yavapai Series.

O'Hara, P. F., 1986a, Previous geologic work in the Prescott-Mayer area, Arizona, *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the southwest: Arizona Geological Society Digest, v. 16, p. 355-357.

O'Hara, P. F., 1986b, Stratigraphy and structural geology in the Prescott-Mayer area, Arizona: *in* Beatty, Barbara, and Wilkinson, P.A.K., eds., Frontiers in geology and ore deposits of Arizona and the southwest: Arizona Geological Society Digest, v. 16, p. 358-364.

Describes the stratigraphy of the Yavapai Series and structural characteristics of the area. Discusses structural and stratigraphic models for the area and revised stratigraphy.

O'Hara, P.F., 1990, Geology of the Big Bug metallic mineral district, Arizona: Arizona Geological Survey Contributed Map Series CM-90-A, scale 1:12,000, 2 sheets.

O'Hara, P.F., Long, R.C., 1991, Geology of Early Proterozoic gold mineralization, alteration assemblages, and geochemistry of the Huron-Victor-Swindler-Montezuma prospects, Yavapai County, Arizona, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 271-278.

Discussion of gold mineralization, alteration assemblages and geochemical analyses of altered metavolcanics.

O'Hara, P.F., Ryberg, G.F., and Niemuth, N.J., 1991, Primary element zonation of veins associated with Laramide stocks in the Groom Creek and Poland Junction 7.5' quadrangles, Yavapai County, Arizona, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 283-290.

Mineralization and zonation patterns of veins, and description of regional geology.

Sayre, J.W., 1979, Mines men and machinery: a study of copper mining in the Bradshaw Mountains, 1875-1979: University of Northern Arizona, M.S. Thesis.

Historical discussion of mining and business dealings of the DeSoto, McCabe-Gladstone and Blue Bell mines. Discussion of the men who worked the mines. Brief history of the Copper Mountain, Valverde and Humboldt smelters.

Wilson, E.D., Cunningham, J.B., and Butler, G.M., 1967, Arizona lode gold mines and gold mining: The Arizona Bureau of Mines Bulletin 137, 254 p.

Includes descriptions of mines and mining activities in the Bradshaw Mountains region.

Wahl, D.E., Jr., and O'Hara, P.F., 1991, Geology of the Golden Belt mine area, Black Canyon metallic mineral district, Arizona, *in* Karlstrom, K.E., ed., Proterozoic geology and ore deposits of Arizona: Arizona Geological Society Digest 19, p. 279-282.

Evaluation of economic feasibility of continued mining or tailings processing.

U.S. Geological Survey, 1950, Aeromagnetic map of the Jerome-Prescott area, Yavapai County, Arizona: U.S. Geological Survey Open File Report 0-50.

U.S. Geological Survey, 1962, Bouguer gravity anomaly map & (aeromagnetic maps) of the Twin Buttes Area, Arizona: U.S. Geological Survey Open File Report 5-62, scale 1:125,000.

U.S. Geological Survey, 1972, Aeromagnetic map of the Bradshaw Mountains and vicinity, Yavapai County, Arizona: U.S. Geological Survey Geophysical Investigations Map GP-758, scale 1:62,500.

Welty, J.W., Reynolds, S.J., and others, 1985, Mine index for the metallic mineral districts of Arizona: Arizona Bureau of Geology and Mineral Technology Bulletin 196, 92 p.

HYDROLOGIC STUDIES

Bedinger, M.S., Anderson, T.W., and Langer, W.H., 1984, Maps showing ground-water units and withdrawal, Basin and Range Province, Arizona: U.S. Geological Survey Water-Resources Investigations Report 83-4114-A, scale 1:500,000, 2 sheets.

Langer, W.H., Mulvihill, D.A., and Anderson, T.W., 1984, Maps showing ground-water levels, springs and depth to ground water, Basin and Range Province, Arizona: U.S. Geological Survey Water-Resources Investigations Report 83-4114-B, scale 1:500,000, 2 sheets.

Littin, G.R., 1981, Maps showing ground-water conditions in the Agua Fria area, Yavapai and Maricopa Counties, Arizona-1979: U.S. Geological Survey Water-Resources Investigations Open-File Report 81-804, scale 1:125,000, 2 sheets.

Maps show depth to water, water level elevation, groundwater flow direction, generalized distribution of hydrogeologic units and water quality data.

Remick, W.H., 1983, Maps showing groundwater conditions in the Prescott Active Management Area, Yavapai County, Arizona--1982: Arizona Department of Water Resources Hydrologic Map Series Report Number 9, scale 1:125,000, 3 sheets.

Maps show depth to water, water level elevation, and water quality data.

Sanger, H.W., and Appel, C.L., 1980, Maps showing ground-water conditions in the Hassayampa area, Maricopa and Yavapai Counties, Arizona-1978: U.S. Geological Survey Water-Resources Investigations Open-File Report 80-584, scale 1:250,000, 2 sheets.

Maps show depth to water, water level elevation, and water quality data.

Thompson, T.H., Nuter, Janet, and Anderson, T.W., 1984, Maps showing distribution of dissolved solids and dominant chemical type in ground water, Basin and Range Province, Arizona: U.S. Geological Survey Water-Resources Investigations Report 83-4114-C, scale 1:500,000, 500,000, 4 sheets.

Included are maps showing well depths, water quality types, and TDS concentrations found in wells.

Wilson, R.P., 1988, Water resources of the northern part of the Agua Fria area, Yavapai County, Arizona: Arizona Department of Water Resources Bulletin 5, 109 p.

Description of groundwater hydrology of the Lonesome Valley, Mayer and Black Hills areas, including recharge and discharge

areas, baseflow, water quality and effects of water resources development. Maps (scale 1 in. = 2 mi.) showing chemical quality, baseflow, hydrogeologic units, well yields and groundwater flow direction are included.

*References with authors and titles printed in boldface are considered most pertinent to the Bradshaw Mountains project.

REFERENCES WHICH HAVE NOT BEEN ANNOTATED

Anderson, Phillip, 1986, The Proterozoic tectonic evolution of Arizona: Tucson, University of Arizona, unpublished Ph.D. dissertation, 416 p.

Arizona Geological Survey (or Arizona Bureau of Geology and Mineral Technology [AZBGMT], file data and clippings (845 N. Park Ave., #100, Tucson, AZ 85719)

Blacet, P.M., 1968, Precambrian geology of the SE1/4 Mount Union quadrangle, Bradshaw Mountains, central Arizona: Palo Alto, California, Stanford University, unpublished Ph.D dissertation, 244 p.

Canty J.M., and Greely M.N., 1987, History of mining in Arizona: Mining Club of the Southwest Foundation, Tucson, Arizona, 279 p.

Daniel B. Stephens and Associates, Inc., 1990, Assessment of abandoned mines and mills on the Prescott National Forest, October 18, 1990.

Darrach, M.E., 1988, A kinematic and geometric structural analysis of an Early Proterozoic crustal scale shear zone: The evolution of the Shylock fault zone, central Arizona: Flagstaff, Northern Arizona University, unpublished M.S. thesis, 78 p.

DeWitt, Ed, 1976, Precambrian geology and ore deposits of the Mayer-Crown King area, Yavapai County, Arizona: Tucson, University of Arizona, unpublished M.S. thesis, 150 p.

Dunning, C.H., 1959, Rocks to riches: Phoenix, Southwest Publishing Company, Inc. 406 p.

Elston, D.P., 1984, Rocks, Landforms and landscape development in central Arizona, *in* Smiley, T.L., Nations, J.D., and others eds., Landscapes of Arizona the geological story: University Press of America, Inc., Lanham, Maryland, 506 p.

Guiteras, J.R., 1936, Gold mining and milling in the Black Canyon area, Yavapai County, Arizona: U.S. Bureau of Mines Information Circular 6905, p. 151-173.

Hargis and Associates, 1991, Cyanide assessment report, McCabe mine, Yavapai County, Arizona, September 20, 1991.

Jerome, S.E., 1956, Reconnaissance geologic study of the Black Canyon schist belt, Bradshaw Mountains, Yavapai and Maricopa Counties, Arizona: Salt Lake City, University of Utah, unpublished Ph.D. dissertation, 160 p.

Los Angeles Chamber of Commerce, 1953, Arizona mines including southwestern New Mexico; The Board of Supervisors of Los

Angeles County, 32 p.

O'Hara, P.F., 1980 Metamorphic and structural geology of the northern Bradshaw Mountains, Yavapai County, Arizona: Tempe, Arizona State University, unpublished Ph.D. dissertation, 117 p.

O'Hara, P.F., 1987, Early Proterozoic gold mineralization, alteration assemblages, and geochemistry of the Huron-Montezuma prospect, Yavapai County, *in* DeWitt, Ed, ed., Proterozoic ore deposits of the southwestern U.S.: Society of Economic Geologists Guidebook Series, v.1, p. 161-166.

Potter, A.N. 1964, The many lives of the Lynx: Prescott Arizona, 167 p.

Prescott National Forest, mine survey data.

Sturdevant, J.A., 1975, Relationship between fracturing, hydrothermal zoning and copper mineralization at the Big Bug pluton, Big Bug mining district, Yavapai County, Arizona: University Park, Pennsylvania State University, Ph.D. dissertation, 285 p.

Webb, W.F., 1979, Precambrian geology and ore deposits near Poland Junction, Yavapai County, Arizona: Tucson, University of Arizona, unpublished M.S. Thesis, 113 p.

Wilson, B.M., 1990, Crown King and the Southern Bradshaws: a complete history: Crown King Press, Mesa Arizona, 104 p.

Vrba, S.L., 1980, Precambrian geology of the Cleator area, Yavapai County, Arizona: Flagstaff, Northern Arizona University, unpublished M.S. thesis, 96 p.

This bibliography, although containing many important citations, is not an exhaustive listing of published and unpublished geologic, mineralogic and hydrologic studies of the Bradshaw Mountains region. Additional geologic and mineralogic references can be found in Arizona Geological Survey Circular 27 cited below:

Welty, J.W., Dewitt, Ed, and Schnabel, Lorraine, 1989, Bibliography for metallic mineral
districts in Gila, Maricopa, Pinal, and Yavapai Counties, Arizona: Arizona Geological Survey Circular 27, 81 p.

APPENDIX 2:
MINING AND MILLING

AGUA FRIA DISTRICT

Mine name: **Binghampton** 7.5 min quadrangle: **Mayer**

Reported years of production: **Pre 1914 - 1947**

Commodities present: **Cu, Ag, Au**

Host rock: **metarhyolite, metatuff**

Deposit type: **vein, disseminated; Veinlets are filled with quartz and dolomite. The ore contained much recrystallized chlorite, and tetrahedrite (with some arsenic) was unusually abundant. (Lindgren, 1926).**

Ore minerals: **chalcopyrite, gold, silver, pyrite, tetrahedrite, sphalerite and arsenopyrite**

Grade and analytical information: **Ore that was mined from 1916 to 1922, was reported as 3% copper.**

Notes on milling, ore shipment, etc.:
The mine was productive from August 1916, to March 1919, and for part of 1920. Ore was again shipped in 1923. Concentrates were reportedly sent to the Humboldt smelter through 1923. As of 1926, the property was owned by W. Reynolds of New York, and the claims by the Arizona-Binghampton Mining Co. The mine and mill were 300 feet above the creek. (Lindgren, 1926)

As of 1926, Workings included a 600-foot shaft, 1,000 feet of adit and about 4,000 feet of additional workings. A 3-compartment shaft was sunk to 1,000 feet. There was a 250-ton flotation mill on the property. (Lindgren, 1926) Ore was produced from the mine during operation from 1940 to 1947. (Dunning, 1959)

Mine name: **Copper Queen** 7.5 min quadrangle: **Mayer**

Reported years of production: **1901 - 1967**

Commodities present: **Cu, Ag, Au, Zn, As**

Host rock: **metarhyolite, metatuff**

Deposit type: **massive copper sulfide; Selective replacement by hydrothermal fluids of existing pyroclastic layers is the most probable origin of most of the mineralization zones in the Copper Queen area. (Higgins, 1986)**

Ore Minerals: **chalcopyrite, tetrahedrite, gold, silver, arsenopyrite, pyrite, sphalerite, tennantite**

Grade and analytical information: ---

Notes on milling, ore shipment, etc.:
The Copper Queen adjoined the Binghampton mine and consisted of about 25 claims, owned by the Copper Queen Gold Mining Company, as of 1926. The mine was developed by a 500-foot inclined shaft, two tunnels (593 and 600) feet in length, and about 8,000 feet of additional workings. A 100-ton flotation mill was at the mine. (Lindgren, 1926)

Mine name: **Stoddard** 7.5 min quadrangle: **Mayer**

Reported years of production: ---

Commodities present: **Cu, Au, Ag, Pb, Zn**

Host rock: **metarhyolite, metatuff** Deposit type: **massive sulfide**

Ore minerals: ---

Grade and analytical information: **Ore produced from 1945 to 1950 was reported to contain 3.82% copper**

Notes on milling, ore shipment, etc.:
Ore produced early in the life of the mine was reduced in a smelter near Stoddard's Ranch, along the Agua Fria River. A 100-ton flotation plant was constructed and brought into operation in 1916. According to Lindgren (1926), development at the mine consisted of extensive upper workings, a lower tunnel 700 feet in length, and a 300-foot winze which extended below the tunnel. The last work done at the site was in 1919. (Lindgren, 1926)

The mine was reopened in 1945, and between 1945 and 1950, about 14,000 tons of ore assaying about 3.82% copper was shipped. (Dunning, 1959)

BIG BUG DISTRICT

Mine name: **Iron King** 7.5 min quadrangle: **Prescott Valley South**

Years of reported production: **1903 - 1969**

Commodities present: **Zn, Pb, Ag, Au, Cu**

Host rock: **metarhyolite, tuff**

Deposit type: **The deposit consists of tabular ore bodies containing alternating bands of massive sulfide and metaandesite, and locally**

massive quartz. (Gilmour and Still, 1968)

Ore minerals: **pyrite, arsenopyrite, sphalerite, galena, chalcopyrite, tennantite**

Grade and analytical information: **Ore produced 1907 - 1964 reported as 0.123 oz. Au/ton, 3.69 oz. Ag/ton, 0.19% Cu, 7.34% Zn.**

Notes on mining, milling, ore shipment, etc.:
The mine was owned in 1934, by the Southwest Mining Company which also owned the Humboldt Smelter. (Wilson and others, 1967) In 1938, a 140-ton bulk flotation plant was installed at the mine.

In 1953, the mine was producing 5,000 tons of ore per month using a 650-ton flotation mill, which was being enlarged at the time. (Los Angeles Chamber of Commerce, 1953) The Iron King mine was in active production in 1953, and was Arizona's largest producer of lead and zinc. At that time the mine was developed by shafts to 1,800 feet with a new 4-compartment shaft in the process of being sunk to 3,000 feet.

as of 1968, the mine was developed by several shafts and drifts with the deepest shaft extending past the 2,400-foot level (Gilmour and Still, 1968) All mill and mining equipment was sold in 1969.

Mine name: **Hackberry Dump/Hackberry Mine**

7.5 min quadrangle: **Poland Junction**

Years of reported production: **1905 - 1956**

Commodities present: **Cu, Au, Ag, Pb, Zn**

Host rock: **rhyolitic tuff** Deposit type: **stratiform massive sulfide**

Ore minerals: **chalcopyrite, galena, sphalerite, auriferous pyrite, tetrahedrite**

Grade and analytical information: **Ore produced from the Hackberry mine from 1943 to 1945 was reported to contain 0.113 oz. Au/ton, 5.18 oz. Ag/ton, 2% Cu, 3.5% Pb, 9% Zn**

Notes on mining, milling, ore shipment, etc.:
The mine was formerly owned by the commercial Mining Company and later by the George A. Treadwell Company. The mine was idle from 1909 until at least 1926. The depth of the shaft in 1926, was 900 feet. (Lindgren, 1926)

In 1943, lead and zinc ore was being shipped to the Iron King mill at Humboldt. The mine dump was reported, in 1979, to contain abundant sphalerite, pyrite and galena with lesser amounts of chalcopyrite. (Arizona Geological Survey files and clippings or

Arizona Bureau of Geology and Mineral Technology (AZBGMT), files)

Mine name: **Lone Pine** 7.5 min quadrangle: **Mayer**

Reported years of production: **1907 - 1956**

Commodities present: **Cu, ag, Au, Pb, Zn**

Host rock: **metarhyolite, tuff**

Deposit type: **stratiform massive sulfide; The orebody occurs at a break between felsic and mafic volcanics and consists, stratigraphically from bottom to top of the rhyolite breccia, a chloritically altered zone, the ore zone and a zone of iron oxide and silica deposition. (Webb, 1979)**

Ore minerals: **chalcopyrite, galena, auriferous pyrite, sphalerite**

Grade and analytical information: **Estimated average ore content was 5.35% Cu, 0.24 oz. Au/ton, 3.16 oz. Ag/ton.**

Notes on mining, milling, ore shipment, etc.:
Several years prior to 1972, a flood washed away part of the waste dump at the mine.

Mine name: **Butternut**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1902 - 1946**

Commodities present: **Au, Cu, Ag, Zn, As**

Host rock: **fine-grained siliceous, sericitic tuff or tuffaceous sedimentary unit (Webb, 1979)**

Deposit type: **stratiform massive sulfide; The ore minerals occur in lenticular streaks with quartz and chlorite. (Lindgren, 1926)**

Ore minerals: **pyrite, chalcopyrite, sphalerite, arsenopyrite**

Grade and analytical information: **Ore was reported to be low-grade. (AZBGMT, files) Records indicate composite assay values of 0.025 oz. Au/ton, 1.16 oz Ag/ton, 1.1% Pb, 4.9% Zn and 1.6% Cu. (Webb, 1979)**

Notes on mining, milling, ore shipment, etc.:
The Big Ledge Mining Company built a smelter at Mayer which operated about a week before closing. In 1923, the Huron Copper Mining Company began operation of the mine but were apparently unsuccessful at realizing a profit. Most of the profitable

production apparently occurred in the early days of the mine. (Dunning, 1959)

Workings, as of 1926, included an 425-foot inclined shaft starting at an angle of 70°, but flattening with depth. The lowest level extended about 600 feet north and south of the shaft. (Lindgren, 1926) A fracture zone trends N.37°E. through the now collapsed shaft of the mine. (Webb, 1979)

Mine name: **Kit Carson**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1907 -1926**

Commodities present: **Ag, Cu, Pb, Au**

Host rock: **metaandesite breccia**

Deposit type: **The northern sector of the Kit Carson vein strikes N.30°E. and dips steeply SE. (Krieger, 1965) The vein is about 1,500 feet west of the Silver Belt-McCabe vein, is about 5 feet wide and occurs in a sheared zone containing sericitic rock and quartz.**

Ore minerals: **argentiferous galena, silver, tetrahedrite, chalcopyrite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The vein was prospected by 8 shafts and prospect pits. Material at the dumps of these openings contained considerable ankerite, but no sulfide minerals were found. (Lindgren, 1926)

Mine name: **Huron**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **? - 1923**

Commodities present: **Cu, Ag, Au**

Host rock: **rhyolitic crystal tuff and tuffaceous sedimentary rocks**

Deposit type: **stratiform massive sulfide**

Ore minerals: **chalcopyrite, gold**

Grade and analytical information: **Two hundred samples were**

collected from variably altered felsic metavolcanic rocks in the Huron-Montezuma prospect. The following mean concentrations were derived from results of the sample analyses: 0.024 ppm Au, 3.5 ppm Ag, 46.7 ppm Cu, 14.8 ppm Pb, 39.8 ppm Zn, 0.04 ppm Hg, 18.6 ppm As, 2.8 ppm Mo and 107.2 ppm Ba. (O'Hara, 1987)

Notes on mining, milling, ore shipment, etc.:
Prospect pits in the area were generally small indicating minor production. Dump samples showed pyritic, siliceous sinter with no other sulfides.

Mine name: **Boggs**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **---**

Commodities present: **Au, Ag, Cu, Zn**

Host rock: **rhyolitic crystal tuff**

Deposit type: **The Boggs mine involves a narrow massive sulfide bed adjacent to more broadly mineralized, pyritic, sericitically altered rhyolite. (Anderson, 1986) The deposit is near the break between the mafic and felsic volcanics. (Webb, 1979) Lindgren (1926) said the ore was similar to that of the Blue Bell (ie. schist replaced with pyrite and chalcopyrite). Some vein-like masses of quartz with epidote, garnet and radiating amphibole were observed.**

Anderson and Blacet (1972) cited Farnham's (1965) description of the orebody as a thin, tabular deposit ranging in thickness from 10 inches to several feet, striking N.20°E. with a steep northerly dip.

Ore minerals: **see notes below**

Grade and analytical information: **A 1943, 98-ton shipment from the 200-foot level assayed 0.45 oz. Au/ton, 5.2 oz. Ag/ton, 1.07 % Cu and 4.3% Zn. (Anderson and Blacet, 1972)**

Notes on mining, milling, ore shipment, etc.:
The Boggs mine is on the same property as the Iron Queen mine. For many years the mine was operated by the Commercial Mining Co. (a subsidiary of the Phelps Dodge corporation), which also owned the Hackberry, Senator and Iron Queen mines. The ore was treated at a smelter near Mayer. From 1905 to 1909, the mine was worked by the George A. Treadwell Co., with ore being treated at a new 250-ton smelter at Mayer. (Lindgren, 1926) In 1919, plans were being made to rework tailings at the mine. (Canty and Greely, 1987) The Liberty Hills Mining Co. leased and operated the mine from 1943 to 1945. In the years 1943 through 1947, 10,400 tons of copper-gold

ore were shipped to the Iron King mill. Prospecting in 1953, failed to reveal any significant value. (Canty and Greely, 1987)

As of 1926, the deepest workings were on the 500-foot level. Minerals in the dump at the mine include sphalerite with lesser amounts of pyrite, chalcopyrite and arsenopyrite. (Lindgren, 1926)

BLACK CANYON DISTRICT

Mine name: **French Lilly** 7.5 min quadrangle: **Cleator**

Years of reported production: **1902 - 1959**

Commodities present: **Au, Ag, Zn, Cu, Pb, As**

Host rock: **quartz-mica schist**

Deposit type: **Ore is associated with a quartz vein, about 2 feet in width.**

Ore minerals: **gold, arsenopyrite, galena, sphalerite, chalcopyrite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
Some high-grade ore was produced from the mine prior to 1907. The mine was idle from 1907 to about 1936, except for some production that occurred in 1922. As of 1936, the property was operated by southwest Metals and Mines, and the main shaft was being deepened, and the management was contemplating erection of a 50-ton flotation mill. Development at that time included a 245-foot shaft inclined at 45° and drifts totalling over 1,000 feet of length. (Guiteras, 1936) In 1953, a 60-ton flotation mill was being operated at the mine. Workings at that time included a 550-foot shaft and 2,000 feet of drifts, and plans were being considered to run a 500-foot drift to the east. (Los Angeles Chamber of Commerce, 1953)

Mine name: **Golden Belt** 7.5 min quadrangle: **Cleator**

Years of reported production: **1919 - 1961**

Commodities present: **Pb, Au, Ag**

Host rock: **metarhyolite, andesite**

Deposit type: **The vein strikes N.60°E. and dips 10° to 23° SE.**

(Wilson and others, 1967) The vein occurs within a fracture zone which is dominated by sheared, highly fractured rhyolite. the zone is filled with iron oxidation material, iron stained quartz pods, breccia and many small quartz veinlets. Hematite-goethite, jarosite, galena, pyrite, sphalerite, chalcopyrite, covellite arsenopyrite, magnetite and very fine-grained silver were observed in the fracture zone. (Clements, 1991)

Ore minerals: gold, galena, chalcopyrite, sphalerite, electrum, hematite, jarosite

Grade and analytical information: Tailings estimated at 0.01 oz. Au/ton, 0.31 oz. Ag/ton. Two samples from different veins averaged 0.88 oz. Au/ton, 4.1 oz. Ag/ton, 5.5% Pb, 608 ppm Cu, 5090 ppm Zn.

Notes on mining, milling, ore shipment, etc.:
The mine was reported as originally located in 1873. (Wilson and others, 1967) The cyanide process was used in early ore dressing. (Guiteras, 1936) Several hundred tons of ore was reportedly produced prior to 1916; part was milled and part was shipped. In 1931, a small mill produced concentrates which were shipped to a smelter. In 1933, ore from the Golden Turkey was treated at the Golden Belt. By 1934, the mine had been developed by an 800-foot shaft and several hundred feet of drifts and stopes. By this time a 50-ton flotation mill was in operation at the mine. (Wilson, 1967)

The following is a brief description of the ore concentration process at the Golden Belt mine: Large pieces of waste rock were picked by hand and sent by mine-car to the waste dump, thus eliminating from the mill feed about 1/3 of the material hoisted from the mine. The remaining ore was crushed (wet or dry). The crushed material was sent to a ball mell after water and flotation reagents sodium xanthates and pine oil) were added. Classifier overflow was run to a 50-ton capacity, 4-cell flotation machine. Middlings were recycled, tailings were moved to the tailings pond and finished concentrates were collected from filters. Sacks of concentrates were then shipped to El Paso for smelting. (Guiteras, 1936)

From 1934 to 1939 the mine was actively producing ore. About 1939, the mine was taken over by the Golden Turkey which was later forced to close. Later the Golden Belt mill was acquired by E.M. Moores, Jr. of Phoenix, Arizona, for treatment of ore from the Gladiator mine.

Mine name: **Golden Turkey** 7.5 min quadrangle: **Cleator**

Reported years of production: **---**

Commodities present: **Ag, Au**

Host rock: **schist, porphyry**

Deposit type: **The vein ranges from inches to more than a foot in width, strikes northeast and dips from 30° to less than 10° SE., and contains quartz.**

Ore minerals: **pyrite, galena, sphalerite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
In 1933, more than 4,000 tons of Golden Turkey ore were run through the golden Belt mill. In 1934, developments consisted of a 500-foot inclined shaft and over 2,000 feet of workings. Most of the ore had come from the 350-foot level. Surface equipment included a 75-ton flotation mill which was erected in the fall of 1934. (Wilson and others, 1934)

The process that was used at the Golden Turkey mill was similar to that used at the Golden Belt, with some exceptions. Aerofloat was added to the ball mill feed and xanthate was added to the classifier overflow. A 6-cell flotation machine and thickeners generated finished concentrates which were shipped to El Paso via Mayer. (Guiteras, 1936)

The mine experienced active ore production from 1935 to 1942, when the mine was closed and remained closed until at least 1959. The mine was never patented. (Dunning, 1959)

Mine name: **Brooks** 7.5 min quadrangle: **Cleator**

Reported years of production: **1915 - 1922**

Commodities present: **Ag, Au, Pb, Cu, Zn**

Host rock: **metarhyolite, chert** Deposit type: **vein**

Ore minerals: **argentiferous galena, ruby silver**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.: **---**

Mine name: **Silver Cord** 7.5 min quadrangle: **Cleator**

Reported years of production: **1910 - 1970**

Commodities present: **Ag, Au, Pb, Cu, Zn**

Host rock: **rhyolite and andesite**

Deposit type: **The mine exploits a shear zone that generally strikes east-west, dips less than 20° SE. and averages 1 meter in thickness. The zone consists of sheared rhyolite, sulfide bearing quartz veinlets, massive quartz, Fe-rich breccia and fault gouge. (Clements, 1991)**

Ore minerals: **proustite, silver, silver chlorite, argentiferous galena, sphalerite, pyrite, gold; Arsenopyrite and chalcopyrite were observed in samples of quartz veinlets. (Clements, 1991)**

Grade and analytical information: **Two samples, one from a quartz veinlet the other from a quartz pod were assayed. The veinlet sample contained 0.13 oz. Au/ton, 18.3oz. Ag/ton, 5.8% Zn, 472 ppm Cu and 6.9% Pb. A sample from a quartz pod contained 0.02 oz Au/ton, 2.7 oz./ton Ag and 2.63% Mn. (Clements, 1991)**

Notes on mining, milling, ore shipment, etc.:
Ore was shipped in the years 1889 through 1914, to smelters at El Paso and elsewhere. Small production was said to occur in 1925, 1928, 1929 and 1930. (Wilson and others, 1967) K.C. McCutchan leased the property for 5 years, through September of 1935, and in 1936, was waiting on a loan for mill construction. (Guiteras, 1936) In 1941, a 50-ton flotation mill reportedly existed at the mine. About 20,000 tons of mill-grade ore were reportedly developed from the property by 1941 (note that no information was found concerning the processing of this ore).

Initial production at the Silver cord was associated with high-grade gold values (>1 oz./ton)within the Upper workings. Later development in the Orphan workings was related to high-grade silver ores (15-40 oz./ton). (Webb, 1979)

As of 1936, the main incline of the mine was driven 300 feet to the southwest at an angle of about 11°. No stoping had been done. During the years of McCutchan's lease ore was removed by picking it from blasted rock piles, and much of it was shipped to El Paso, with some going to Hayden and the Magma Copper Co. (Guiteras, 1936)

Mine name: **Thunderbolt** 7.5 min quadrangle: **Bumble Bee**

Reported years of production: **1911 - 1968**

Commodities present: **Ag, Pb, Zn, Au, Cu; Silver was the most valuable commodity and occurred in a mixture of galena and sphalerite. (Guiteras, 1936)**

Host rock: **metarhyolite, metaandesite**

Deposit type: **The quartz vein ranges from 4 to 12 inches in width, strikes to the east and dips 44°N.**

Ore minerals: **proustite, galena, sphalerite, silver**

Grade and analytical information: **An assay average was reported as 8 oz. Ag/ton, 1% Pb and 1.5% Zn.**

Notes on mining, milling, ore shipment, etc.:
The property was originally located in 1905. As of 1936, workings included a 1,600-foot main adit and a rise. (Guiteras, 1936)

A flotation plant was being assembled at the mine in 1919. (AZBGMT files) In 1935, a 25-ton flotation mill began intermittent operation. The mill included a jaw crusher, conveyance system, ball mill, drag classifier and a 2-cell flotation machine. Tails from the flotation machine were sent to concentration tables, and concentrates from the tables were recycled to the ball mill. Reagents added to the ore included xanthate 301, xanthate 208, Aerofloat 31 and cresylic acid.(Guiteras, 1936)

A 50-ton flotation plant was reportedly in operation in 1942, and concentrates were being shipped to the El Paso Smelter. After being closed, the mill was reopened in 1948, and was operating at 50-tons per day. (AZBGMT files)

GROOM CREEK

Mine name: **Home Run**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1903 - 1940**

Commodities present: **Cu, Pb, Ag, Au**

Host rock: **slate, metabasalt** Deposit type: **vein**

Ore minerals: **---**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
In 1932, high grade ore was reportedly shipped to the Magma smelter at Superior. Plans to build a 15-ton mill at the mine were being made in 1934. (AZBGMT files) There is currently an active mining claim at the site. (Prescott National Forest, 1993)

Mine name: **Midnight Test**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1902 - 1935**

Commodities present: **Au, Ag, Pb, Cu, Zn**

Host rock: **slate, metabasalt**

Deposit type: **The deposit is comprised of generally narrow quartz veins with scattered ore minerals. (Wilson, 1967)**

Ore minerals: **galena, pyrite, sphalerite, gold, shear zone fractures were marked with hematite and limonite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The mine was developed by a 400-foot shaft prior to 1906, with a small mill operating for a short period of time. In 1919, the mine yielded some milling ore. (Wilson, 1967) In 1920, a stamp mill was reported to be complete for the amalgamation process. A 50-ton mill was reportedly added at the site in 1924. (AZBGMT files)

After 1922, the National Gold Corporation conducted considerable underground exploration and built a 200-ton mill for amalgamation, flotation and table concentration. Several ore and concentrate shipments were made.(Wilson, 1967) In 1930, a 200-ton crusher, ball mill concentration tables and flotation machines reportedly were at the site. (AZBGMT files)

A visitor to the site reported in 1931, that a 40-ton pilot flotation and concentration mill was on site. In 1933, plans were reportedly being considered for construction of a 500-ton mill. (AZBGMT files) In 1934, the main shaft was 600 feet deep. (Wilson, 1967) Ther is currently an active mining claim at the site. (Prescott National Forest, 1993)

Mine name: **Gold Basis (Gold Basin)**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1901 - 1940**

Commodities present: **Cu, Pb, Ag, Au**

Host rock: **slate, metabasalt** Deposit type: **vein**

Ore minerals: **---**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The property includes 5 claims. In 1918, the property was equipped with a 5-stamp mill, but the ore was not easily treated in this manner. At the time mine workings included a 325-foot shaft with several levels. (Yavapai Magazine, 1918)

In 1936, ore shipments of 300 tons per month were reported. A dry processing plant consisting of crushing and sizing equipment and an air flotation system was reportedly being installed in 1935. (AZBGMT, files)

Mine name: **Alma** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1907 - 1947**

Commodities present: **Cu, Pb, Ag, Au**

Host rock: **slate, metabasalt** Deposit type: **vein**

Ore minerals: **---**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
In 1937, development of the mine was said to active, with shipment of high-grade ore being made. In 1945, lead-gold ore was reportedly being stockpiled. (AZBGMT files)

Mine name: **Monte Cristo (King Kelly)**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1904 - 1942**

Commodities present: **Ag, Pb, Au, Cu**

Host rock: **slate, metabasalt**

Deposit type: **The King Kelly is a quartz-filled fissure vein which strikes N.15°W. and dips steeply or vertically to the west. (Lindgren, 1926)**

Ore minerals: **pyrite, galena** Grade and analytical information: **---**

Notes on mining,milling, ore shipment, etc.:
The mine was said to have made considerable production in 1920. (Lindgren, 1926)

Mine name: **Cornucopia** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1902 - 1941**

Commodities present: **Cu, Ag, Au**

Host rock: **slate, metabasalt** Deposit type: **vein**

Ore minerals: **some molybdenite in ore**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
Some ores were reportedly shipped to El Paso and the Magma smelter in the 1930's. (AZBGMT, files)

Mine name: **Pine Grove** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1933 - 1940**

Commodities present: **Cu, Pb, Zn, Au, Ag**

Host rock: **slate, metabasalt** Deposit type: **vein**

Ore minerals: **chalcopyrite, argentiferous galena, silver, gold, sphalerite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
In 1934, it was reported that a 10-stamp mill consisting of stamps, plate and table were operating at the mine and that bullion shipments were being made to the mint. A 10-ton amalgamation and gravity concentration plant was said to be operating in 1937. Production capacity was reportedly increased to 25-tons in 1939. (AZBGMT, files)

HASSAYAMPA

Mine name: **Oro Flame** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1910 - 1955**

Commodities present: **Cu, Ag, Au, Pb, Zn**

Host rock: **Granodiorite, diorite, rhyolite porphyry dikes**

Deposit type: **The quartz veins occur in a zone which strikes N.20°W.**

and dips 76°NE. (Wilson and others, 1967)

Ore minerals: **galena, pyrite, gold, chalcopyrite, sphalerite; Gold occurs mainly in sulfides, particularly in galena. (Wilson and others, 1967)**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
Prior to 1908, considerable production was reportedly made with a 20-stamp mill. From 1928 to 1934, the mine was worked by the H. K. Grove Company, the Oro flame Mining company and the Oro Grande Mining Company. The Oro flame and Sterling mines (both on the same property), produced about 80 cars of ore from 1928 to 1933, mostly from the Oro flame. (Wilson, 1967)

By 1934, the mine had been developed by a 320-foot inclined shaft, an adit and several hundred feet of drifts. A new mill existed on the northwestern side of Hassayampa Creek. (Wilson and others, 1967) A local newspaper reported that a 40-ton flotation and concentration mill had been completed in 1934. (AZBGMT, files) This is probably the same mill referred to by Dunning (1959). According to Dunning Howard Fields and associates leased the mine in 1934, built a small mill and produced some gold through 1936. Little work was done at the mine from that time until at least 1959. (Dunning, 1959) A nearby vein called the Gold Bug had also been developed by 1934. (Wilson and others, 1967)

Mine name: **Golden Charm (Golden Eagle)**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1926 - 1936**

Commodities present: **Cu, Ag, Au**

Host rock: **metatuff, schist**

Deposit type: **The veins typically consist of small lenses and bunches of quartz (Wilson and others, 1967)**

Ore minerals: **disseminations of pyrite and chalcopyrite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The Golden Eagle property consists of about 8 claims. Part of the property was located in 1880. Small production was made by the property in 1925 and 1926.

As of 1934, workings consisted of about 2,000 feet of tunnels and two 100-foot shafts. A 25-ton concentrator, with ball mill,

amalgamation plates and a table also existed at the mine.

Mine name: **Ruth*** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Pb, As, Zn, Cu, Au; Production in 1911-1913, 1916 and 1926, yielded mostly Pb, Zn and Ag ores and concentrates. (Wilson and others, 1967)**

Host rock: **granodiorite**

Deposit type: **The quartz vein dips steeply to the west and contains narrow seems of tourmaline, ankerite and pyrite. (Wilson and others, 1967)**

Ore minerals: **pyrite, chalcopyrite, galena, sphalerite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
In 1915, a new 50-ton mill was reportedly at the mine. (AZBGMT, files) As of 1934, the mine was opened by a 300-foot shaft and had a gold mill. (Wilson and others, 1967)

***There are two Ruth mines listed in the Mineral Resources Data System (MRDS) data base, with nearly identical locational information assigned to them. Data was used from the listing which fell under the Hassayampa District.**

Mine name: **Independence** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1906 - 1942**

Commodities present: **Cu, Ag, Au**

Host rock: **amphibolite, slate** Deposit type: **vein**

Ore minerals: **sulphides**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The Independence was apparently being prospected in 1906. (Potter, 1964) The mine was reportedly equipped with Huntington mills and a 50-ton cyanide plant in 1913. (AZBGMT, files) There is currently an active claim at the site. (Prescott National Forest)

Mine name: **Blue Dick** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1902 - 1928**

Commodities present: **Cu, Ag, Au, Zn, Pb**

Host rock: **amphibolite, slate**

Deposit type: **The fissure vein strikes north and dips west. (Lindgren, 1926)**

Ore minerals: **chalcopyrite, gold, sphalerite, galena, tetrahedrite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
the mine was a rich producer of silver in the 1890's. (Dunning, 1959) About that time attempts were reportedly being made to smelt low grade ore at the mine. (AZBGMT, files) In 1926, the mine was owned by Judge Bushnell of Cleveland, Ohio. Workings at that time included a tunnel. (Lindgren, 1926) some production occurred in 1935, when ore was hauled to the mill at the Davis-Dunkirk mine. (Dunning, 1959)

MAYER

Mine name: **Blue Bell** 7.5 min quadrangle: **Cleator**

Reported years of production: **1896 - 1959**

Commodities present: **Cu, Ag, Au, Pb, Zn, As**

Host rock: **metarhyolite, chert**

Deposit type: **stratiform massive sulfide; Lindgren (1926) said that "In the smelting ore, a little calcite is universally present, but the principal gangue is quartz", and that veinlets of calcite and quartz were abundant in the mine. Guiteras (1936) said that the ore body was about 100 feet in width.**

Ore minerals: **pyrite, chalcopyrite, tetrahedrite, gold, bornite, chalcocite, arsenopyrite, sphalerite, galena**

Grade and analytical information: **The mine has yielded a large quantity of low-grade ore.**

Notes on milling, ore shipment, etc.:
The mine became an important producer in 1906. (Lindgren, 1926) The years 1911 through 1920, were high production years for the Blue Bell. (Canty and Greely, 1987) In 1918 ore was being sent to

Humboldt for concentration and smelting. (AZBGMT, files) As of 1926, the mine was owned by the Consolidated Arizona Smelting Company. Apparently, the 350-ton concentration plant at Humboldt was used to treat ore from the mine. (Lindgren, 1926) The mine was idle between 1938 and 1943, some copper, silver and gold production occurred between 1945 and 1947, but little further work was done at the mine. (Canty and Greely, 1987)

Development as of 1926, consisted of a 1,400-foot vertical shaft with nearly 30,000 feet of levels, and five smaller shafts. The developed length of the deposit was 1,600 feet. (Lindgren, 1926)

Mine name: **Desoto** 7.5 min quadrangle: **Battle Flat**

Reported years of production: **1890 -1972**

Commodities present: **Cu, Au, Ag, Pb, Zn, As, Fe**

Host rock: **metarhyolite, chert**

Deposit type: **stratiform massive sulfide; The deposit is comprised of a 200 by 350-foot ore zone, with a fine-grained quartz gangue. (Lindgren, 1926)**

Ore minerals: **pyrite, chalcopyrite, sphalerite, galena, tetrahedrite, arsenopyrite, gold, magnetite, hematite, ilmenite**

Grade and analytical information: **The 1922 ore grade was reported as 3.75% Cu, 1 oz. Ag/ton, and 0.02 oz. Au/ton. Results of an ore sample analysis conducted in 1961 were: 28.3% Fe, 0.9% Mn, and 0.2% TiO_2.**

Notes on mining, milling, ore shipment, etc.:
The mine was discovered in 1875, and originally called the Buster mine. The mine was largely inactive from 1904 to 1915. (Sayre, 1979) Work at the mine was again discontinued in 1922, because the ore bodies were considered to be exhausted. (Lindgren, 1926) During the mine's heavy shipping days an aerial tram was installed for transportation of the ore from the mine, down the hill to Middleton to the Crown King railroad. (Dunning, 1959)

As of 1926, the workings included a main tunnel, which was 600 feet below the outcrop. The property was then owned by Southwest Metals Co., also owners of the Humboldt smelter (where ore from the Desoto was shipped). (Lindgren, 1926)

In the following years, to 1930, work was intermittent at the mine, and little has been done since that time. (Sayre, 1979) Dunning (1959) reported that some production had been recorded since 1930.

MOUNT UNION

Mine name: **Davis-Dunkirk** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1874 - 1961**

Commodities present: **Cu, Ag, Au, Pb, Zn**

Host rock: **Amphibolite**

Deposit type: **The vein is filled with quartz and ankerite with abundant pyrite and chalcopyrite, and ranges from inches to 3 feet in width. (Wilson and others, 1967)**

Ore minerals: **pyrite, sphalerite, polybasite, silver, chalcopyrite, ruby silver, argentite, gold, proustite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The veins were located in the 1860's or early 1870's. some production occurred during this period. In 1925, the property was acquired by Davis-Dunkirk Mines Inc., which built a 120-ton flotation mill. Regular operations began in 1933 and continued into 1934. Concentrates were said to be sent to El Paso for smelting. (Wilson and others, 1967) Apparently many outlying mines hauled ore to the Davis-Dunkirk mill (Dunning, 1959).

In 1934, workings at the mine consisted of over 6,000 feet of adits, raises, stopes and winzes, with a vertical range of over 1,600 feet. (Wilson and others, 1967) As of 1953, the mine comprised 10 patented and 3 unpatented claims and was developed by approximately 11,000 feet of workings including 1,000 feet of shafts and raises and 1,500 feet of crosscuts. At that time only development work was being done, including stoping. (Los Angeles Chamber of Commerce, 1953)

Mine name: **Mount Union** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Pb, Au, Ag, Cu, Zn**

Host rock: **granodiorite**

Deposit type: **vein, shear zone; Two veins are reported to occur at the property, one ranging from 6 to 10 feet in width. (Wilson and others, 1967) The veins are closely associated with rhyolite porphyry dikes. (Lindgren, 1926)**

Ore minerals: **pyrite, sphalerite, galena, chalcopyrite,**

tetrahedrite

Grade and analytical information: ---

Notes on mining, milling, ore shipment, etc.:
In 1906, some lead ore with gold and silver was produced. A small (Huntington) mill was used at the mine for a short time. Reports indicate that the ore was of low grade and difficult to amalgamate. (Wilson and others, 1967)

Plans were reportedly being made for construction of a 50-ton mill in 1952. (AZBGMT, files) By 1953, the mine was developed by 1,200-foot tunnel. (Los Angeles chamber of Commerce, 1953)

Mine name: **Storm Cloud** 7.5 min quadrangle: **Groom Creek**

Reported years of production: ---

Commodities present: **Au, Ag, Cu, Pb**

Host rock: **granodiorite, amphibolite schist** deposit type: **vein, shear zone**

Ore minerals: **pyrite, specularite, chalcopyrite, galena, sphalerite**

Grade and analytical information: ---

Notes on milling, ore shipment, etc.:
Prior to 1926, some ore was shipped to the Humboldt smelter. (Lindgren, 1926) A 100-ton flotation mill was reportedly treating 50-tons of ore per day in 1928. The mill was said to be equipped with a crusher, ball mill, classifier and flotation machines. (AZBGMT, files)

Mine name: **Cash** 7.5 min quadrangle: **Groom Creek**

Reported years of production: ---

Commodities present: **Pb, Ag, Au**

Host rock: **amphibolite, slate**

Deposit type: **The vein strikes N.40°E. and dips 60°SE. (Lindgren, 1926) Jagger and Palache (1900) described the deposit as an ore body in the form of a series of lenses with a maximum thickness of 2.5 feet.**

Ore minerals: **galena, sphalerite, pyrite, chalcopyrite, magnetite, specularite, adularia; Some ore seen in the dumps in 1922, contained magnetite, specularite, adularia and sphalerite coated**

with covellite. (Lindgren, 1926)

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
Prior to 1883, the mine was opened by three shallow shafts. From 1900 to 1902, the mine was extensively worked. Lindgren (1926) said that the mine was developed by a 400-foot shaft and had a 10-stamp mill with plates and concentration. In 1918, it was reported that a 30-ton stamp mill was operated on site and that some ore was sent to the Huntington mill at Mount Union mine. (AZBGMT, files)

After a period of inactivity, the mine was reopened in 1922, by the Betty O'Neil Mining Company of Nevada, but production was nominal. (Dunning, 1959) Plans were being made in 1929, to build a flotation device to replace the existing cyanide mill. (AZBGMT, files)

The mile-long Senator tunnel cuts the Cash vein at a depth of about 600 feet. Ore produced from the tunnel from 1949 through 1952, was shipped to the Iron King mill. (Dunning, 1959)

Mine name: **Senator** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Cu, Ag, Au, Pb, Zn**

Host rock: **Amphibolite, slate, rhyolite porphyry dikes**

Deposit type: **veins; The Senator mine was principally a gold property consisting of several parallel veins which strike north-northeast. The Senator vein carried lead-zinc ores only and contained mostly gold with some silver. Other veins were the Ten Spot, containing mostly pyrite, the Treadwell with pyrite, specularite and gold and the Snoozer carrying copper ores and specularite.**

Ore minerals: **pyrite, chalcopyrite, specularite, galena, sphalerite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The deposit was opened prior to 1871, and worked from 1883 to 1899. It had been owned by Phelps dodge since 1889. a concentrator was erected in the early 1890's for treatment of base gold ores. (Daniel B. Stephens and Associates, Inc. 1990) A shaft was sunk to 835 feet, intersecting a tunnel which extended to the Cash mine. (Wilson and others, 1967) Ore from early production was reportedly treated in arrastres. A 10-stamp mill was operated at the mine in the late 19th century. In 1927, the possibility of ore shipment to the Humboldt smelter was being considered. In 1930, ore was being shipped to the Copper Queen smelter at Douglas. (AZBGMT, files)

A recent site visit (Daniel B. Stephens and Associates, Inc. 1990) revealed the following: Drainage was flowing from a 5x7 foot adit. Approximately 120,000 cubic yards of spoils were located below the adit on a slope above the Hassayampa River. Drainage flows from the mine, across the spoils and into the river. Mill tailings about 0.2 miles downstream from the Senator were apparently sampled.

Mine name: **Big Pine** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1910 - 1918**

Commodities present: **Ag, Au**

Host rock: **granodiorite, diorite**

Deposit type: **The vein strikes N.35°W. and dips 70°NW., and contains quartz and pyrite. (Lindgren, 1926)**

Ore minerals: **Pyrite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
Workings at the mine, as of 1926, included four tunnels and a 200-foot shaft with drifts 200 and 350 feet long. A cyanide plant was on the property, but had apparently been used little. (Lindgren, 1926)

Mine name: **Crook** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Cu, Pb, Zn, Ag, Au**

Host rock: **granodiorite**

Deposit type: **vein, shear zone; The quartz and ankerite vein ranges up to 4 feet in width, strikes N.10°W. and dips 75°SW. The vein is traceable for over a mile in a S.10°E. direction, and is said to continue to the Venezia mill. (Lindgren, 1926)**

Ore minerals: **galena, pyrite, sphalerite, chalcocite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
During the early days of the mine the oxidized zone was reportedly worked by open cuts, generally less than 40 feet deep, with arrastres. (Wilson and others, 1967) Substantial gold production

was realized in the late 1800's. (Dunning, 1959) The Pan American Mining Co., worked the vein into the year 1902. (Wilson and others, 1967)

The owners of the Crook mine reportedly had a contract in 1915, for shipment of ore to the mill at Venezia. In 1916, a 5-stamp mill was reported to be in operation at the Crook mine, with concentrates being shipped to El Paso. (AZBGMT, files)

As of 1918, the principal development of the mine was a 400-foot tunnel with a 40-foot winze and a 30-foot drift. a 300-foot crosscut tunnel from the alligator claim intersects the vein at a depth of 166 feet, with drifts driven 564 feet to the north and 550 feet to the south. (Yavapai Magazine, 1918)

Mine name: **Venezia** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1910 - 1939**

Commodities present: **Au, Ag, Cu, Mo**

Host rock: **granodiorite** Deposit type: **vein**

Ore minerals: **molybdenite**

Grade and analytical information: **---**

Site ID on 7.5 min quad: Dump on site:

Dump(s) within 1/2 mile radius:

Notes on milling, ore shipment, etc.:
In 1915, a mill was reported to be treating ore from the Crook mine. (AZBGMT, files) Prior to 1927, sulphide ores were mined from the Crook, Venezia, Starlight and Mount Union mines (all owned by Reilly Gold Mines) and treated by a 20-stamp mill at Venezia. From 1927 to about 1932, the "Trapshooter" Westerner Gold Mining Co. milled about 100 tons of gold ore. After 1932, some bullion and concentrates were shipped, but operations were suspended in 1933. (Wilson and others, 1967)

Mine name: **Money Metals** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Au, Pb, Zn, Cu, Ag**

Host rock: **granodiorite**

Deposit type: **The quartz vein was 175 feet long and 2 to 5 feet wide at the 200-foot level. (Wilson and others, 1967)**

Ore minerals: **galena, sphalerite, pyrite, chalcopyrite**

Grade and analytical information: **Much of the vein was reported to contain 0.5 oz. Au/ton**

Notes on mining, milling, ore shipment, etc.:
The deposit was located in 1897, by F. Reif who shipped some ore from the upper levels and then sold the property. The mine was reopened in 1928, after a period of inactivity, and operated by the Yavapai Gold and Silver Mining Co. The workings, as of 1934, included a 300-foot shaft inclined 68°W., and approximately 1,400 feet of drifts. A 20-ton concentrator powered with two dodge motors was used at the mine. (Wilson and others, 1967) There is currently an active mining claim at the site. (Prescott National Forest)

Mine name: **Sheldon Superior**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1935 - 1954**

Commodities present: **chalcopyrite, argentiferous galena**

Host rock: **granodiorite, rhyolite** Deposit type: **vein**

Ore minerals: **Cu, Ag, Au, Pb**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
In 1929, a 100-ton mill was reportedly being constructed and plans were being considered for a 200-ton capacity addition. A 75-ton flotation plant was reported to have been completed in 1948. (AZBGMT, files)

PECK

Mine name: **Swastika** 7.5 min quadrangle: **Battle Flat**

Reported years of production: **1876 - 1976**

Commodities present: **Ag, Pb, Cu, Au, Zn**

Host rock: **chert, schist** Deposit type: **vein**

Ore minerals: **silver, cerargyrite, silver chloride, silver bromide, tetrahedrite, argentiferous galena, chalcopyrite**

Grade and analytical information: ---

Notes on mining, milling, ore shipment, etc.:
Prior to 1885, a 4-stamp mill was treating ore at the mine from the Black Warrior and Silver Prince veins. The mine was idle from 1885 to 1910. some development occurred from 1910 to 1915, and only intermittent activity from 1915 through 1936.

Workings included 3 adits at the 100, 200 and 300 foot levels, totalling about 600 feet in length. A winze was sunk 200 feet below the 300-foot level adit, with drifts drive on the 400 and 500-foot levels.

From August, 1934, to the year-end, nine 50-ton cars of ore were shipped for processing, and 29 cars were shipped from January to October, 1935. In January, 1936, a new 50-ton flotation mill began treating ore from the dump at the mine. Components of the mill included a slusher, grizzly, jaw crusher, ball mill, classifier, launder and a 6-cell flotation machine. Additives to the ball mill feed include sodium sulphide, xanthate, Aerofloat and pine oil. About 3 tons of water per ton of ore were used in the process. (Guiteras, 1936)

The first concentrates from the new mill were shipped to El Paso in February of 1936. (Guiteras, 1936) The ore proved difficult to treat by milling and production was consequently intermittent into 1952. By 1959, the mine was owned by the Holmerdix Mining Corporation. (Dunning, 1959)

Mine name: **Peck** 7.5 min quadrangle: **Battle Flat**

Reported years of production: **1875 - 1948**

Commodities present: **Au, Cu, Zn, Ag, Pb**

Host rock: **chert**

Deposit type: **Three parrallel veins, several feet wide in places and striking N.25°E. and dipping 75°W. were in the mined area. (Lindgren, 1926)**

Ore minerals: **cerargyrite, bromyrite; The ore consisted mostly of dark-brown quartzite replaced partly with limonite. Principal gangue minerals were siderite and ankerite, mostly converted to limonite. (Lindgren, 1926)**

Grade and analytical information: ---

Notes on mining, milling, ore shipment, etc.:
The mine was discovered in 1875, by E.G. Peck, and in the early days 10 tons of ore was sold at Prescott. In 1883, the mine was

productive. (Lindgren, 1926) Apparently most of the production at the Peck took place from about 1875 to the early 1900's. (Dunning, 1959)

The workings at the mine consisted of a 400-foot shaft and levels which aggregated to 1,400 feet in length. In the 1880's a 10-stamp mill was in use at the mine, but work was intermittent from 1885 to at least 1926. As of 1926, the mine was owned by O. Tawney. (Lindgren, 1926)

In 1919, it was reported that a 50-ton ball mill with tables and cyanide tanks was being used to treat over 20,000 tons of silver ore produced in the 1870's (note that this production figure is contrary to classification of this mine as a producer of less than 5000 tons of ore). A carload of ore per month was reportedly being shipped from the mine in 1945. (AZBGMT, files)

RICHINBAR

Mine name: **Richinbar** 7.5 min quadrangle: **Joes Hill**

Reported years of production: **1905 - 1948**

Commodities present: **Au, Ag, Pb Cu**

Host rock: **granodiorite**

Deposit type: **The vein strikes north and dip is near vertical to the west. Gangue minerals include quartz, tourmaline and carbonate. (Wilson and others, 1967)**

Ore minerals: **gold, pyrite, chalcopyrite, galena, sphalerite, hematite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
From 1905 to 1908, the Richinbar Mines Co., extensively developed the property. A 20-stamp mill was built and 8,000 tons of ore was reportedly mined. (Guiteras, 1936)

Prior to 1930 a 40-stamp mill was operated at the mine. In 1934, a 100-ton milling plant was reportedly installed. Components of the mill included: ball mill, classifier, flotation machine, thickener and settling ponds. (AZBGMT, files)

In early, 1933 and 1934, the Sterling Gold Mining Corporation acquired the property, made some surface improvements and did some underground work. At that time the main shaft was 500 feet deep and

was reportedly connected with several thousand feet of workings. (Wilson and others, 1967)

In 1935, ore was being extracted from all levels of the mine. In 1936, drifts were being driven at the 300-foot level and ore was being stoped at the 200-foot level. the mill components, as of 1936, included: a crusher, ball mill, classifier, an 8-cell flotation machine, a concentration table and settling tanks. Flotation reagents (pine oil, Barret no. 4, xanthate 301 and xanthate 208) were added to the ball mill feed. (Guiteras, 1936)

TICONDEROGA

Mine name: **Arizona National**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **---**

Commodities present: **Ag, Au, Pb, Zn, Cu**

Host rock: **metaandesite breccia, diorite**

Deposit type: **The vein ranges in thickness from inches to several feet, strikes N.20°E. and dips 70°W. (Lindgren, 1926) The occurrence of the ore is essentially the same as that at the Silver Belt. (Anderson and Creasey, 1958)**

Ore minerals: **galena, sphalerite, pyrite, chalcopyrite, argentite, tetrahedrite; The ore contains ankerite, carbonate, calcite, manganese, barite and a little quartz. (Lindgren, 1926)**

Grade and analytical information: **Ore produced from 1922 to 1925, was reported to contain 20 oz. Ag/ton.**

Notes on milling, ore shipment, etc.:
As of 1922, the mine was owned by Anderson and Company and had been operating for 7 years.the mine was developed by a 230-foot shaft, with a winze extending 185 feet from the bottom level. The mine was equipped with a 50-ton ball mill and concentrating tables.

Production continued through 1931, but the mine was inactive until at least 1958, at which time the mine was inaccessible. By then the mine was developed by two shafts, one about being about 520 feet deep with lateral workings at 7 levels. (Anderson and Creasey, 1958)

Mine name: **Lelan-Dividend**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1906-1937**

Commodities present: **Au, Ag, Pb, Cu, Zn**

Host rock: **granodiorite, rhyolite**

Deposit type: **Ore occurred in a lenticular quartz vein. (Wilson and others, 1967)**

Ore minerals: **gold, argentiferous galena, chalcopyrite, sphalerite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
In 1858, 60-tons of ore was reportedly treated at the Big Bug (Henrietta) mill (about half a mile north of Big Bug Creek and one mile west of Poland siding). A 10-stamp mill was operated at the mine from 1900 to 1914. (Wilson and others, 1967)

In 1932 and 1933, the Southwestern Exploration Company erected a 100-ton flotation and concentration plant. The plant was operated in 1933, but operations were suspended at the end of the year. (Wilson and others, 1967) Concentrates were reportedly shipped to El Paso in 1933. (AZBGMT, files) Dunning (1959) said that the mine was still idle in 1959. Development was said to extend to 500 feet. (Dunning, 1959)

Mine name: **Little Jesse**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1867 - 1942**

Commodities present: **Au, Ag, Cu, Pb, Zn**

Host rock: **granodiorite, rhyolite** Deposit type: **vein**

Ore minerals: **gold, auriferous pyrite; High-grade auriferous pyrite was encountered between the 500 and 600 foot levels. (Lindgren, 1926)**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
The deposit was discovered in 1867. From about 1890 to 1898, a mill worked by J. S. Jones produced bullion and concentrates. Much development work was done from 1909 to 1916. (Wilson and others, 1967)

Lindgren (1926) states that in 1922, the shaft was 659 feet deep. In early 1934, the Arizona Consolidated Mining Company was reportedly installing a new mill. (Wilson and others, 1967)

Mine name: **Red Rock** 7.5 min quadrangle: **Poland Junction**

Reported years of production: **1906 - 1942**

Commodities present: **Au, Ag, Cu**

Host rock: **metaandesite breccia**

Deposit type: **The vein strikes N.35°E. and dips steeply southeast, and where seen was 2 feet in width. The vein contained quartz, pyrite and zinc blende. (Lindgren, 1926)**

Ore minerals: **---**

Grade and analytical information: **Primary ore was probably of low grade. (Lindgren, 1926)**

Notes on milling, ore shipment, etc.:
The Red rock vein was worked about 1906, and the mine was developed by many tunnels. Most of the ore was developed from the oxidized zone, which was richer in free gold. Ore was reduced in an amalgamating mill with tables. (Lindgren, 1926)

Mine name: **Postmaster**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1902 - 1942**

Commodities present: **Au, Ag, Cu, Pb, Zn**

Host rock: **metaandesite**

Deposit type: **The vein strikes northeast. (Lindgren, 1926)**

Ore minerals: **gold, argentiferous galena, chalcopyrite, sphalerite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
Prior to 1926, ore was concentrated at the Oriental Custom mill, which was near the mine. (Lindgren, 1926) In 1940, shipments were reportedly made to the Magma smelter in Superior, and in 1941, ore was said to be shipped to the Clarksdale smelter. (AZBGMT, files)

Mine name: **Silver Belt**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1870 - 1924**

Commodities present: **Ag, Pb, Au, Cu, Mn, Ba, Zn**

Host rock: **metaandesite breccia**

Deposit type: **Lindgren (1926) said that reports indicate that the vein is 15 to 20 feet wide, strikes N.30°E., carries rich silver and is more or less similar to the Peck mine deposit.**

Ore minerals: **galena, sphalerite, silver; The ore contained much magniferous ankerite and barite (Lindgren, 1926)**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
The mine was located about 1870, and sold in 1878, to Thorne and Simms. Three shafts, one of which was sunk to 252 feet, existed at the mine. The vein was worked from 1870 to 1889, with ores initially shipped to San Francisco, and later sent to Humboldt for smelting. In 1906, owner H.B. Clifford had the shaft sunk to 400 or 480 feet. All that remained at the site in 1926, was a scattered dump. (Lindgren, 1926) As of 1958, the mine had been inactive for many years. (Anderson and Creasey, 1958)

Mine name: **Independence 2**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **1910 - 1922**

Commodities present: **Au, Ag, Cu**

Host rock: **granodiorite, rhyolite** Deposit type: **vein**

Ore minerals: **gold, chalcopyrite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.: **---**

Mine name: **Crown King** 7.5 min quadrangle: **Crown King**

Reported years of production: **---**

Commodities present: **Au, Ag, Zn, Cu, Fe, Pb**

Host rock: **metasedimentary, quartzite**

Deposit type: **The Crown King vein averages 2 feet in width, strikes north-northeast and dips 70°W. (Guiteras, 1936)**

Ore minerals: **sphalerite, pyrite, chalcopyrite, gold**

Grade and analytical information: **Ore was reported to average 0.5 oz. Au/ton and 4 oz. Ag/ton. Tailings from the old mill were reported to contain 0.3 oz. Au/ton, 4.5 oz Ag/ton, 11% Zn, 0.8% Cu and 10% Fe. Zinc product contained 43% zinc, 10% Fe, 11% zn, 4.5% Cu, 15 oz. Ag/ton and 0.6 oz Au/ton. Iron product contained 1.5 oz. Au/ton, 10 oz. Ag/ton, 12% Zn, 30% Fe, 2.5% Cu.**

Site ID on 7.5 min quad: **yes** Dump on site: **yes**

Dump(s) within 1/2 mile radius: **yes**

Notes on milling, ore shipment, etc.:
A 10-stamp mill was being constructed at the mine in 1888. (S. Brad) From 1890 to 1895, the property was operated by the Crown King Mining Company. Stamp mill middlings were stockpiled and concentrates sent to Prescott during that time period. (Wilson and others, 1967)

From 1895 to 1901, the mine, at that time owned by H. B. Chamberlain and Co., of Denver, was expanded to follow an ore shoot to a depth of 650 feet. During 1906 and 1907, the crown King Mines Co., worked the middlings pile and shipped concentrates containing gold, silver, zinc iron and copper. (Wilson and others, 1967)

In 1916, a more modern mill was built by the lessee organized Bradshaw Reduction Co., which included: ball mills, classifiers, Wilfley tables and flotation cells. Tailings were then worked for zinc concentrates. The mill was wrecked by a flood in the winter of 1926-1927. (Wilson and others, 1967)

In the years 1933 and 1934, a 300-ton flotation mill was built (Wilson and others, 1967). Mine workings as of 1936, included a 480-foot shaft, a 913-foot tunnel (150 feet below the collar) and a 500-foot winze with 5 levels, each extending about 1200 feet north and from 200 to 500 feet south. Activities in 1936, consisted

of driving two adits to intersect ore in the Union claim. (Guiteras, 1936) The cyanide process was used to reduce ore in the 1980's.

Mine name: **Wildflower** 7.5 min quadrangle: **Crown King**

Reported years of production: **---**

Commodities present: **Cu, Ag, Au, Zn, Pb**

Host rock: **metagabbro**

Deposit type: **vein, shear zone; The deposit is associated with a fissure vein with quartz-sulfide filling, ankeritic carbonates and calcite. (Lindgren, 1926)**

Ore minerals: **sphalerite, chalcopyrite, pyrite**

Grade and analytical information: **Results of a 1922, sample analysis were: 6 oz. Ag/ton, 2.5% Cu, and 12% Zn.**

Notes on mining, milling, ore shipment, etc.:
The Wildflower group comprised about 13 patented claims. Development at the mine consisted of a 700-foot inclined shaft with levels at 110, 200, 300 and 480 feet. (Guiteras, 1936) In 1916, a 2-mile aerial tramway linked the Wildflower to the Crown King mill for ore transportation. The mine was worked from 1917 to 1919, and about 13,000 tons of ore were milled. Apparently the mine was closed shortly thereafter. Lindgren (1926) notes that in 1922, the mine was inaccessible but plenty of ore was in the dump.

Mine name: **Lincoln** 7.5 min quadrangle: **Crown King**

Reported years of production: **---**

Commodities present: **Au, Ag, Zn, Pb, Cu**

Host rock: **schist (amphibolitic in part), quartzite**

Deposit type: **vein**

Ore minerals: **pyrite, chalcopyrite, sphalerite, galena, tetrahedrite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
The mine was worked in 1902, and from 1905 to 1908, producing about 10,000 tons of ore. (Wilson and others, 1967) The mine was equipped with a 15-stamp amalgamating mill (Lindgren, 1926), and developed by a long tunnel. After 1908, production was small. In 1931, a few

cars of ore were shipped, but the mine had been inactive from that time through 1959. (Dunning, 1959)

Mine name: **Union** 7.5 min quadrangle: **Crown King**

Reported years of production: **1916 - 1914**

Commodities present: **Ag, Cu, Au, Pb, Zn**

Host rock: **granodiorite** Deposit type: **vein**

Ore minerals: **argentiferous galena, chalcopyrite, gold, galena, sphalerite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
In 1936, the mine was idle. Repairs were reportedly being made in 1942, to a 25-ton flotation plant in preparation for active mining. The mill was said to consist of a ball mill, classifier and 4 flotation cells. (AZBGMT, files)

Mine name: **Del Pasco** 7.5 min quadrangle: **Crown King**

Reported years of production: **---**

Commodities present: **Au, Ag, Pb, Zn, Cu**

Host rock: **schist, quartzite**

Deposit type: **The vein contains quartz, is 2 to 3 feet in width, strikes northeast and dips 70°W.**

Ore minerals: **sphalerite, pyrite, galena**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
The mine was discovered in July 1870, and by August 1870, two arrastres were in use at the mine. In 1871, a 4-stamp mill was operating at the mine. In 1873, ore from the War Eagle was run through the Del Pasco mill. The mine was worked through the 1870's, but only sporadically in the 1880's. (Wilson, 1990) In 1922, an arrastre was being used at the mine. (Lindgren, 1926) Production was reported for the years 1942 and 1943. (Dunning, 1959)

TURKEY CREEK

Mine name: **Bodie*** 7.5 min quadrangle: **Battleship Butte**

Reported years of production: **? - 1951**

Commodities present: **Pb, Ag, Cu, Au**

Host rock: **granodiorite, gabbro** Deposit type: **vein**

Ore minerals: **auriferous galena, lead carbonates**

Grade and analytical information: **Assays were reported as yielding 40% Pb and 61 oz. Ag/ton**

Notes on milling, ore shipment, etc.:
As of 1926, the mine was owned by the Murphy estate. Development as of 1883, included a 480-foot tunnel and 100-foot shaft. Considerable additional development to the workings had occurred by 1926. (Lindgren, 1926)

***Two listings for the Bodie mine, both mines being located in the Turkey Creek district, are in the ore production data base.**

Mine name: **War Eagle** 7.5 min quadrangle: **---**

Reported years of production: **1872 - 1949**

Commodities present: **Ag, Au, Pb, Zn, Cu**

Host rock: **granodiorite, gabbro**

Deposit type: **The deposit is associated with a narrow (at most 2 feet in width) quartz vein which strikes north and dips steeply west. (Lindgren, 1926)**

Ore minerals: **galena, sphalerite, tetrahedrite, chalcopyrite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
Lindgren (1926) described the property as an old property of 4 claims. apparently, the mine was located prior to 1874. In 1922, Mr. McMaster of the Gallup, New Mexico owned the property. The mine shaft at that time was 300 feet deep. (Lindgren, 1926)

Mine name: **Sheldon** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Cu, Pb, Au, Ag, Zn**

Host rock: **granodiorite** Deposit type: **vein, shear zone; The quartz and calcite vein pinches and swells but averages 4 or 5 feet in thickness. The vein strikes N.30°E. and dips 70 to 80°SE. (Wilson and others, 1967)**

Ore minerals: **pyrite, sphalerite, chalcopyrite, galena, tetrahedrite, chalcocite**

Grade and analytical information: **Sample analysis conducted in 1922, yielded: 2.76% copper, 3.5% Pb, 0.25 oz. Au/ton and 8.5 oz. Ag/ton.**

Notes on mining, milling, ore shipment, etc.:
Prior to 1922, the mine was open by a 650-foot vertical shaft with several hundred feet of drifts at the 250, 450 and 650 foot levels. (Wilson and others, 1967) In 1923, ore was reportedly shipped to the Humboldt smelter. (AZBGMT, files) Although the AZBGMT files indicate that a 250-ton concentrator was in operation in 1924, Wilson and others (1967) said that a 200-ton concentration and flotation plant was built in 1924, and that several thousand tons of ore were treated in ensuing years to 1930. During that period the shaft was deepened to 1,280 feet and several thousand feet of development work was done. (Wilson and others, 1967) In 1926, production was reported as 90 tons per day. (AZBGMT, files)

The mine was idle in the early 1930's, but was reopened in 1936, and was active through 1942. The mine was again idle until 1952, when the Allison Steel Co., built a 200-ton mill and dewatered the mine. Only 7,500 tons of low grade ore were milled before the mill was closed later that year. (Dunning, 1959)

Mine name: **Poland mine**

7.5 min quadrangle: **Poland Junction**

Reported years of production: **---**

Commodities present: **Cu, Pb, Zn, Ag, Au**

Host rock: **granodiorite**

Deposit type: **The vein strikes northeast and dips steeply northwest. (Lindgren, 1926)**

Ore minerals: **pyrite, sphalerite, galena; Ore on the dump contained quartz, pyrite, sphalerite and galena. (Lindgren, 1926)**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
In 1900, Frank Murphy acquired the mine and established the Poland Mining Company. At this time the mine consisted of an 800-foot tunnel. (Canty and Greely, 1987) A shaft was reportedly sunk 325 feet below the tunnel level. (Lindgren, 1926) Frank Murphy also owned the Development Company of America, which operated many mines in the Lynx Creek area. (Canty and Greely, 1987)

Intermittent production occurred at the mine from 1900 through 1912, with operation of a 20-stamp mill. (Lindgren, 1926) A later report indicated that a 50-ton concentration plant was located on the edge of a nearby creek. (AZBGMT, files) The Poland tunnel was completed in 1904. In 1907, production slowed and the mine closed in 1912. (Canty and Greely, 1987)

Some additional, small production occurred in 1926, 1930 and 1931. In 1934, the property was further investigated, but without fruitful results. Occasional small shipments were made as late as 1954. (Dunning, 1959) A shaft was reportedly sunk 325 feet below the tunnel level. Ore was reportedly produced from the mine in 1954.

Mine name: **Mudhole** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Au, Ag, Cu**

Host rock: **granodiorite rhyolite**

Deposit type: **The deposit is associated with 2 parallel veins, each 6 to 8 feet wide. (Wilson and others, 1967)**

Ore minerals: **chalcopyrite, pyrite**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The mine was worked to some extent prior to 1897, and was active from 1897 to 1893. (Wilson and others, 1967) In 1900, a mill was constructed for amalgamation and concentration. Ore and concentrates were reportedly shipped to Humboldt, El Paso and Needles. The main shaft was 740-feet deep and inclined 47°. Other workings include a tunnel and another shaft. Ore from the mine

contained abundant magnetite, and tunnel dumps were found to be rich in galena and sphalerite. (Lindgren, 1926).

The mine was practically idle from 1903 to 1936. (Wilson and others, 1967) As of 1959, the mine had been inactive since 1913, and apparently was never patented. (Dunning, 1959)

Mine name: **Amulet** 7.5 min quadrangle: **Poland Junction**

Reported years of production: **---**

Commodities present: **Ag, Au, Pb**

Host rock: **granodiorite** Deposit type: **vein; shear zone**

Ore minerals: **pyrite, chalcopyrite**

Grade and analytical information: **High grade ore was reported to have 459 oz. Ag/ton and 46% Pb.**

Notes on mining, milling, ore shipment, etc.:
Work was done on the Amulet from 1887 to 1891, when high grade ore was shipped. The Amulet was reportedly the extension of the Mudhole veins. A shaft was sunk to 200 feet shortly before 1926. (Lindgren, 1926)

In 1934, a 50-ton pilot mill was reportedly treating ores from nearby dumps. A flotation plant was reported to be treating 100-tons of ore per day in 1935. In 1936, ore from the Sheldon dump was reportedly being treated in a 150-ton capacity mill. (AZBGMT, files) The final closing of the Amulet mine was in 1935 or 1936. (Potter, 1964)

Mine name: **Pine Mountain**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **---**

Commodities present: **Ag, Au, Pb, Zn**

Host rock: **granodiorite, rhyolite** Deposit type: **vein**

Ore minerals: **galena, sphalerite, pyrite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:

The mine was apparently located in the 1860's by Norman L. Griffen. In 1894, a quartz mill, built in the old smelter building at Howells, was operating steadily. Later the mill was moved to the Pine Mountain claim, initially as a 5-stamp mill and then enlarged to a 10-stamp mill. In 1903, the mine's 400-foot shaft was retimbered. In 1906, the mine was active and in 1908, the mine reportedly had a vertical extent of 500 feet and was equipped with a 50-ton mill. The tunnel later connected the Pine Mountain shaft to the Morning Star mine. The mine was apparently owned by the Pine Mountain Company. Intermitent work occurred at the mine until the late 1940's. (Potter, 1964)

Reparations were reportedly being made on a mill in 1915, in preparation for ore processing. In 1934, a 10-stamp mill was reportedly operating intermittently on feed from a dump said to contain several thousand tons of ore.

Mine name: **Black Diamond**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1910 - 1919**

Commodities present: **Pb, Cu, Ag, Au**

Host rock: **granodiorite** Deposit type: **vein**

Ore minerals: **---**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.: **The mine was located by Chas W. Tryon in June, 1876. (Potter, 1964) The year 1910, was apparently a good production year for the mine. A ball mill was hauled to the mine about 1918.**

Mine name: **New strike** 7.5 min quadrangle: **Prescott**

Reported years of production: **1936 - 1967**

Commodities present: **Cu, Pb, Zn, Ag, Au**

Host rock: **rhyolitic tuff**

Deposit type: **The mine is located on a shear zone which strikes about N.12°W. and dips 80°W. rocks in the shear zone contain quartz, sericite, carbonate, chlorite and epidote. (Krieger, 1965)**

Ore minerals: **sphalerite, galena**

Grade and analytical information: ---

Notes on mining, milling, ore shipment, etc.:
The prospect was explored by an adit and several shallow shafts and pits for about 1,500 feet. Ore was shipped from the property in 1942, 1943, 1946 and 1949 and the prospect was reopened briefly in 1952. (Krieger, 1965)

Mine name: **Oro Plata** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1940 - 1949**

Commodities present: **Au, Ag, Pb, Cu**

Host rock: **granodiorite** Deposit type: **vein**

Ore minerals: ---

Grade and analytical information: ---

Notes on mining, milling, ore shipment, etc.: ---

Mine name: **Combination** 7.5 min quadrangle: **Groom Creek**

Reported years of production: **1948 - 1975**

Commodities present: **Au, Ag, Zn, Pb, Cu**

Host rock: **granodiorite** Deposit type: **vein**

Ore minerals: **sphalerite, galena**

Grade and analytical information: ---

Notes on milling, ore shipment, etc.:
Shipments of ore were reportedly made in 1945. (AZBGMT, files)

Mine name: **Blue John, Wedge**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1902 - 1928**

Commodities present: **Au, Ag, Cu, Pb**

Host rock: **granodiorite, rhyolite** Deposit type: **vein**

Ore minerals: **tetrahedrite reported**

Grade and analytical information: **---**

Notes on mining, milling, ore shipment, etc.:
The Blue John mine was located in January 1913, by J. M. R. Purrot. The mine was operated in 1914, producing ore yielding gold and silver and also shipping grade ore containing lead. apparently the mine was equipped with a mill. (Potter, 1964) According to the AZBGMT files a 5-stamp mill was proposed for erection in 1921. The Wedge, which lies on the west side of the Blue John claim, was located by W. B. Shanks and Sam Dryer in 1916. (Potter, 1964)

The following was observed during a recent site visit (Daniel B. Stphens and Associates, Inc. 1990): A stamp mill and a small spoils pile were at the site. The spoils pile appeared to be on Forest Service land. No mine drainage or other surface water was observed.

Mine name: **Hidden Treasure**

7.5 min quadrangle: **Groom Creek**

Reported years of production: **1935 - 1951**

Commodities present: **Au, Cu, Pb, Zn**

Host rock: **granodiorite** Deposit type: **vein; shear zone**

Ore minerals: **gold, sphalerite, galena, marcasite, chalcopyrite**

Grade and analytical information: **---**

Notes on milling, ore shipment, etc.:
The mine was located in 1879, by the Yavapai Mill and Mining company. In 1880, a tunnel was driven about 200 feet and according to Potter (1964) a 12-foot vein containing very high grade ore was encountered. Plans were made to erect a 10-stamp mill and assay office. (Potter, 1964) apparently 200-tons of ore from the Hidden Treasure, No. Capitol and Eberhardt mines was treated at the Poland mill in 1910.

Ore Processing Methods

The literature concerning milling at the mines selected for this study indicates that ore processing methods included the use of arrastres, amalgamation techniques and mills equipped with flotation machines. Brief, generalized descriptions of these and other treatment methods are provided below.

ARRASTRES

Arrastres were used early in the Bradshaw Mountains mining history and essentially consisted of a pit with a grinding mechanism, often powered by mules. Mercury may have been added to the ore for the extraction of gold.

AMALGAMATION

Amalgamation is a concentrating process where mercury is used to draw metallic gold or silver into an amalgam (metal-laden mercury). The ore containing the precious metals must be ground fine enough to release them, and should be suspended in water or at least moved by water. (Taggart, 1945) Amalgamation processes include plate amalgamation and grinding amalgamation. After the precious metals have been taken into the amalgam, the mercury is distilled and collected, leaving the precious metal.

FLOTATION

The flotation process involves the removal of particles from an aqueous medium. This is accomplished by the selective attachment of air bubbles (or some other gas), or oil to the desired particles. These particles are then separated from the aqueous medium into a froth which can be removed. The flotation process can be subdivided into froth, film and oil flotation. Froth flotation is the most widely used process.

Oil flotation consists of selective wetting of mineral surfaces by oil (eg. kerosene, etc.). Oil covered particles collect and float to the surface of the aqueous medium.

In the film flotation process, crushed ore is sprinkled onto the water surface. The unwettable particles float and are removed. The portion removed is called the flotation product.

Froth Flotation:

The froth flotation process is aided by three groups of reagents called collectors, frothers and regulators. The collectors adsorb to mineral surfaces, rendering them water repellant and facilitating air-bubble attachment. Frothers assist in froth development. Regulators are used to either activate or depress mineral attachment to air bubbles. Frothers may also be used in pH regulation.

collectors:

Collectors are organic substances, a typical example of which is sodium oleate ($C_{17}H_{33}COONa$). For sulfide mineral flotation xanthogenates are among the most effective and highly selective collectors. Dithiophosphates are also important in sulfide flotation.

frothers:

Frothers are organic substances which help to keep air bubbles dispersed. Pine oil is the most widely used frother. Cresol or cresylic acid ($CH_3C_6H_4OH$) is also a widely used frother.

regulators:

Regulators are used to intensify (activators) or reduce (depressants) the water-repellant effect of a collector on a mineral surface. Cyanides can be used to separate sulfides from one another (eg. galena from sphalerite). Depressants, which are used in sulfide ore processing include cyanides, sulfites and chromium salts.